S. A. E. JOURNAL

Published by the Society of Automotive Engineers, Inc., 29 *W. 39th St., New York*

Issued monthly, $1 a number, $10 a year; foreign $12 a year; to members, 50 cents a number, $5 a year. Entered as second-class matter, Jan. 14, 1928, at the post office at New York, N. Y., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized on Jan. 14, 1928.

W. R. Strickland, *President* Coker F. Clarkson, *Secretary* C. B. Whittelsey, *Treasurer*

Vol. XXIV April, 1929 No. 4

CONTENTS

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

S. A. E. JOURNAL

Vol. XXIV April, 1929 No. 4

Activities Focus on Saranac

MANY members have questioned why, if Saranac warrants all the favorable comment that has been submitted, the Society has not considered Saranac as a Summer Meeting place before. The answer is that an addition to Saranac Inn, built only last year, now provides sufficient facilities to house the S.A.E. Summer Meetings. Always exclusive, Saranac Inn has until this year been unable to accommodate comfortably more than 500 guests. Today the hotel proper will take care of 500, and the many cottages and bungalows, within a few minutes' walk of the hotel, will accommodate 330. Reservation blanks, listing the accommodations available, will be mailed to members about April 10, together with information regarding special trains.

Located in the very northern part of New York State, Saranac Inn is in the heart of the Adirondacks, one of the most beautiful mountain and lake regions east of the Rockies. The hotel is located on a neck of land extending out into Upper Saranac Lake. There is water on three sides of the hotel, and the cottages and bungalows extend along the shore to the mainland. The Inn is in the center of a large tract of land, being practically isolated from all other communities in the Adirondacks.

Mark These Dates on Your Calendar

June 25-26

Transportation and Cottages

Special motorcoaches will be pressed into service to carry the members of the Society from the trains at the special Saranac railroad station on the main line, two miles distant from the Inn. The community nearest to Saranac Inn is the town of Saranac, 20 miles distant.

It is anticipated that many Sections, companies and groups of members will want to reserve complete cottages for the meeting. The cottages range from dwellings with spacious verandas and large living rooms, accommodating 30 guests, to small woodland bungalows accommodating eight guests. All cottages have the best of furnishings, and are thoroughly modern in every respect.

Committees Arranging Program

The technical program for the Summer Meeting is being arranged by several committees. The Meetings Committee, under the able chairmanship of John A. C. Warner, will sponsor two general evening sessions. The Motor Vehicle Committee, under the chairmanship of George L. McCain, will be sponsor for three motor-vehicle sessions, at which cylinder-head-design, mixture-distribution and front-wheel-drive problems will be featured. The Transportation Committee, under the chairmanship of F. C. Horner, is arranging for a transportation session, at which long-distance motorcoach transportation will be discussed. There will also be the regular session on research, sponsored by the Research Committee.

A subject that has proved of great interest at recent meetings has been the relation of engineering to business. Members will remember Norman Shidle's paper at the Quebec meeting, and the joint paper by J. D. Mooney and Clarence M. Foss at the Annual Meeting. The Meetings Committee will shortly announce the author of the Summer Meeting address on this subject. It is expected that he will be the sales executive of one of the leading motor-car companies.

Arrangements are also being made for several demonstrations of interesting scientific developments in other industries.

Committees are being appointed by the Meetings Committee to handle all Summer Meeting sports, which will include golf, tennis, swimming and archery. There will also be a Field Day, but present plans for this contemplate no event in which skill or strength will play a deciding part. Facilities will also be available for canoeing and horseback riding. Those who prefer to trust their own legs will find many interesting mountain trails.

Swimming and Water Sports Will Be Right at the Front Door of Saranac Inn

And There Is Golf, Tennis, Riding, Mountain Trails, Archery, Canoeing

Meetings Calendar

1929			APRIL			1929
SUN.	MON.	TUES.	WED.	THUR.	FRI.	SAT.
	1	2 BUFFALO CHICAGO	3 MILWAUKEE	4	5	6
7	8	9 DETROIT	10 CANADIAN DETROIT PENNSYLVANIA	11	12 SOUTHERN CALIFORNIA	13 INDIANA
14	15	16	17 CLEVELAND NEW-ENGLAND	18 METROPOLITAN	19	20 NORTH WEST
21	22	23	24	25	26	27
28	29	30				

National Meetings

Aeronautic—April 9 and 10

Book-Cadillac, Detroit.

Summer—June 25 to 28

Saranac Inn, Saranac Lake, N. Y.

Western Aeronautic—June or July

Wichita, Kan.

Cleveland Aeronautic—Aug. 26 to 28

Hollenden Hotel, Cleveland.

Production—Oct. 2 to 4

Hotel Cleveland, Cleveland.

Transportation—October or November

Detroit, Cleveland or Chicago.

Annual Dinner—Jan. 9, 1930

New York City.

Annual—Jan. 21 to 24, 1930

Book-Cadillac, Detroit.

Section Meetings

Buffalo—April 2

Technical Requirements of Fire Fighting and Fire Protection—Hubert Walker, American LaFrance & Foamite Corp.

Canadian—April 10

Dinner Meeting.

Chicago—April 2

Recent Developments in Headlighting—Chester A. Ricker, Day-Nite, Inc.; and R. E. Carlson, Westinghouse Lamp Co.

Cleveland—April 17

Speaker: C. F. Kettering, General Motors Research Laboratories.

Detroit—April 9 and 10

Joint National and Section Meeting during Aircraft Show.

Indiana—April 20

Production Meeting—Inspection of Hagerstown and New Castle, Ind., plants of Perfect Circle Co.; entertainment and dinner at New Castle.

Metropolitan—April 18

Economic Justification of Tendencies in Light Car Powerplants—Alex Taub, Chevrolet Motor Co.

Metropolitan Aeronautic Division—April 4

Spinning Characteristics of Airplanes and Control Thereof—Dr. Michael Watter, Chance Vought Corp.

Inspection Methods for Quantity Production of Engines—George J. Mead, Pratt & Whitney Aircraft Co.

Engine Cowling—Kenneth M. Lane, Wright Aeronautical Corp.

Milwaukee—April 3

Airplane Meeting—Speakers: George J. Mead, Pratt & Whitney Aircraft Co.; and Arthur Nutt, Curtiss Aeroplane & Motor Co.

New England—April 17

Diesel Engines—Philip B. Jackson, Aluminum Co. of America; and C. L. Cummins, Cummins Engine Co.

Northwest—April 20

Motorcoach Maintenance—C. C. Humber, Longview Public Service Co.

Pennsylvania—April 10

Vibration Control—Thomas J. Litle, Jr., Marmon Motor Car Co.

Southern California—April 12

The Cadillac Transmission—Jack Frost, Don Lee Co.

The Graham-Paige Transmission—H. H. Jones, Graham-Paige Co. of Southern California.

The Seven-Speed Truck Transmission—John Wiggers, Moreland Motor Truck Co.

Oil Specifications and Fuels

Round and MacCoull Give Papers at the March Metropolitan Section Meeting—Organization of Motorboat Division Urged

TWO former chairmen of the Section were head-liners at the March 21 meeting of the Metropolitan Section. An attendance of 110 at the dinner filled the Colonial Room of the Park Central Hotel where the meeting was held. Late comers brought the number of those who heard the papers and discussion to about 200. As remarked by Chairman Sidney Dresser, the decoration of the room seems particularly appropriate for an S.A.E. meeting, since it shows so many kinds of transportation. A transportation demonstration was staged also, when waiters rolled into the room the top of a round table to accommodate guests whose reservations had not been made early. This suggests to an American engineer that King Arthur's table may not have been made round because of any premature idea of democracy.

At the opening of the meeting, Chairman Dresser called on Gerald T. White, formerly editor of *Rudder* and now chief engineer of Fairchild Boats, Inc., the small-boat division of the Fairchild Aviation Corp., who spoke in favor of organization of a motorboat division of the Section. He mentioned the community of interest between builders of automobiles and builders of motorboats, remarking on the production last year of 5000 hulls in a single plant, and of the 50,000 outboard engines supplied by five manufacturers. Government-registered boats now number about 1,000,000, including only those on tidewater. There are nine publications in the Country devoted to boating, with a combined subscription-list of 125,000. Experienced automotive engineers are needed in all lines of motorboat work, particularly in production, said Mr. White, and there is a need for motorboat activities that is mutual with the Society and the manufacturers.

Chairman Dresser reinforced the statement of mutual need, saying that during his first year in the marine industry one automobile manufacturer did a marine business equal in dollar volume to that of any of the old established marine companies.

Customary Oil-Tests Questioned

Factors Governing Oil Performance was the subject of the address of George A. Round, of the Vacuum Oil Co., which was begun by reading extracts from a report of one of the committees of the American Society for Testing Materials, on The Significance of Tests of Petroleum Products, in which the practical value of the customary tests, such as those for gravity, pour point, flash and fire point, is discounted. Mr. Round said that most of these tests, when applied to oils of various types, are inaccurate as measures of the actual usefulness of the oil. The Army, the Navy and one of the departments of the State of New York have abandoned their specifications for purchasing oil and substituted something in the nature of approved lists. Tests are used still to test the identity of oils of the same type.

Viscosity is said by Mr. Round to be one of the most important qualities of oil, because of its effect on friction and oil consumption. He has found it very difficult to find accurately the oil-consumption rate. Even so small a detail as the position of the crankshaft when the oil is drained may affect the accuracy. Oiliness is another important factor, since it differentiates oils from other viscous liquids. Vegetable oils are more oily than mineral oils, but Mr. Round's tests indicate that if an engine requires castor-oil as a lubricant it is because clearances are too small.

The pour test does not measure the engine-starting qualities of an oil. Mr. Round has found a "dragometer," consisting of a bearing with means for measuring the friction, used in connection with a check test on an engine, to be a reasonably accurate check of this quality. He concluded that it is necessary to secure the best possible balance of the various qualities required in an oil, and use specifications and tests only for identification.

Gasoline Substitutes Are Remote

The paper on gasoline, by Neil MacCoull, of The Texas Co., gave a very interesting picture of the general fuel situation. Last year nearly 14,000,000,000 gallons of gasoline was burned in the United States, which would make a lake 5 miles in diameter and almost 4 ft. deep, he said. The absurdity of some of the proposals for substitutes is shown by the facts that the total output of molasses, made into alcohol, would yield only 1/20 of this quantity, and all the soft coal mined, if coked, would result in only 1/10 as much benzol. Incidentally, the cost of the fuel from coal would be about 50 cents per gal.

In the early days of the motor-car, the gasoline yield was about 20 per cent of the petroleum. A decade ago, a great shortage of gasoline was predicted by 1926; but the cracking processes, increasing the yield of gasoline, prevented even an increase in price. By present processes, the gasoline yield is from 65 to 75 per cent and can be controlled to meet the relative demands for gasoline and kerosene. In the more strictly technical parts of his paper, Mr. MacCoull discussed volatility and antiknock characteristics as the more important qualities of gasoline.

Good Discussion Contributed

A number of prominent oil men and research engineers contributed discussion of the two papers, particularly on the subject of oils. W. H. Conant, of the J. G. White Management Corp. and the New York Lubricating Oil Co., suspects that engineers love their specifications too well. Sometimes the specifications boost the cost without a corresponding increase in value; for instance, tests for emulsifying quality and cold tests sometimes are misleading. Dr. J. C. Geniesse, of the Atlantic Refining Co., Philadelphia, said that it is easier to improve the oil consumption by changes in the engine than in the oil, and cited a case in which an extra oil-pan caught leakage amounting to 80 per cent of the consumption. H. Eugene Pengilly, of the Standard Oil Co., recommended the selection of oil by the resulting fuel economy rather than by the consumption of the oil itself.

Dr. A. C. Purdy, of Bull & Roberts, remarked on the many gasolines of low grade on the local market, high sulphur-

content being the chief offense. Sulphur should be limited to 0.10, or at the most 0.15, per cent. Oscar Eskuche, of the Warren-Nash Co., recommended the selection of a gasoline giving the best results in regard to knocking, saying that such a gasoline will also yield the best economy.

Fleet Economics Considered

Detroit Section Studies Operation and Maintenance, and Inspects New Research Laboratories

MORE than 700 members and guests were in attendance when Chairman B. J. Lemon called the session of the Detroit Section to order at the meeting held March 11. It was stated at the brief business session that the committee for nominating officers of the Section is composed of W. T. Fishleigh, E. W. Seaholm, L. M. Woolson, G. L. McCain and W. C. Keys; that for officers of the Body Division of the Section, W. N. Davis, A. A. Cripps and L. C. Hill; and that for the Aeronautic Division, L. M. Woolson, J. T. Whitaker and W. E. Lees. These names were affirmed by vote. Following the session, an opportunity was afforded by the General Motors Corp. for inspection of its new research laboratory, recently put into commission, in which building the meeting was held.

The upper five floors of this 11-story building are devoted to research work, there being a total of approximately 200,700 sq. ft. of usable laboratory floor-space. The construction is reinforced concrete, with a brick and limestone exterior finish. Two freight elevators, of 12,000 and of 20,000-lb. capacity, are provided, and also three for passengers and one between the first and sixth floors for the use of drivers. The cold room is located on the ground floor, the machine-shop on the seventh, and the experimental garage on the eighth floor, where also are located the chassis and engine dynamometers and facilities for rear-axle testing. The ninth floor is devoted to the head-lamp and the powerplant sections, and has, as facilities for the investigation of special problems, a large dark-room, a small test-room and balancing machines.

The executive offices, exhibit rooms, library and electrical testing sections are on the tenth floor, as is also the laboratory of C. F. Kettering, general director of the Laboratories. Metallurgical, chemical, physical and fuel-testing facilities are provided on the eleventh floor, on which is the auditorium seating 480.

Equipment provided in the auditorium includes two motion-picture machines, a stereopticon and all facilities for making demonstrations. The stage is elevated 3 ft. above the floor and is equipped with footlights. For demonstration purposes, an adjacent pit is equipped with connections for cold and hot water, drainage, gas, compressed air and electricity.

Economics Applied to Operation

The paper presented by F. K. Glynn, of the American Telephone & Telegraph Co., was entitled The Economics of Motor-Vehicle Operation and Maintenance. He remarked that, although a great deal has been said in the last few years concerning the engineering features of the design of automotive equipment, little has been said of the increasing technical requirements of operating a motor-vehicle fleet. The superintendent of a fleet, in his opinion, is called upon to:

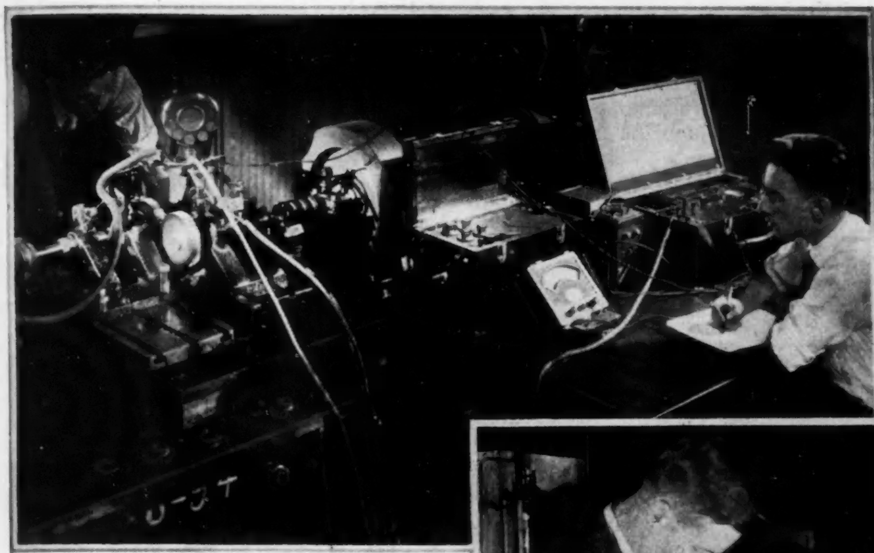
(1) Build up an efficient operating organization
(2) Determine the most efficient type, make and size of chassis, body, accessories and auxiliary equipment for the job
(3) Determine the economic time for replacement
(4) Arrange for the purchase of all automotive equipment, maintain an adequate stock of parts and supplies, and arrange for the disposal of replaced equipment
(5) Determine the practices to be followed in the daily maintenance and in the repair of the vehicles
(6) Design, lay out, equip and locate garages to house the fleet
(7) Collect, compile and study operating data to effect improvements and economies
(8) Measure operating results
(9) Study the use of the vehicles in the field with a view toward increased productivity and the elimination of lost time
(10) Determine the qualifications of the drivers and train them in the safe operation and efficient care of the vehicles
(11) Review proposed motor-vehicle laws
(12) Handle registrations and licenses

TESTING TORSIONAL STRENGTH OF AN AXLE

Two Organization Plans

Mr. Glynn analyzed two distinctly different plans for fleet organization; one, that of providing for sufficient man-power to care for all repairs, and the other, of later origin and requiring a much smaller organization, the delegation of all repairs to the specialists of the commercial repair-shops. In analyzing the former plan, he considered a fleet of 500 vehicles; his analysis of the latter plan had to do with a fleet organization having no shop personnel and a total of about 10 vehicles per employe, the fundamental requirements in this case being the provision of qualified inspector-repairmen and efficient manufacturers' and commercial service-stations.

Concerning economical service life, Mr. Glynn said that no set rules have been found effective, but that it has been demonstrated that a critical point is reached in the life of a chassis beyond which it is uneconomical to make extensive repairs. This point is indicated when the cost of immediate repairs, plus the estimated running maintenance — disregarding depreciation—during the period of extended life, is greater per unit, that is, per mile, hour, ton-mile and the like, than the cost of running maintenance plus actual depreciation for the first-life period of a new chassis. The critical point for each class or make of chassis can be approximated from past records and, as each chassis approaches this point in service, consideration should be given to its replacement. He stressed individual consideration of each chassis for the reason that, depending upon the driver's expertness, the territory covered and the work performed, some chassis will operate economically in ex-



(TOP) RECORDING GEAR NOISE BY USE OF VACUUM-TUBE AMPLIFIER AT GENERAL MOTORS LABORATORIES

(RIGHT) STUDYING ENGINE CHARACTERISTICS WITH AN UPTODATE SINGLE-CYLINDER DESIGN

(LEFT) DETERMINING CARBURETER PERFORMANCE IN A MERCURY-SEALED BOX

(BOTTOM) SPECTROSCOPIC DETECTION OF IMPURITIES IN METALS BY COLORS OF METALLIC VAPORS

cess of others, and therefore the calendar and the odometer are not exclusive evidence in chassis replacement.

Numerous lantern slides were exhibited illustrative of body design for a public-utilities fleet and the possibilities of the motor-vehicle as a means of saving manual labor. Charts showing desirable methods of cost-accounting were presented and comments made thereon. In conclusion, Mr. Glynn besought hearty cooperation between the manufacturers, the operators and the Society, so that the efficiency and utility of motor-vehicles may thereby be increased continuously. Great interest in the subject was manifested by the prolonged discussion following the paper.

Annual Dinner-Dance

AS a mid-season break in its monthly technical meetings, the Southern California Section held its third annual dinner-dance the evening of March 15. Two hundred members and their families attended. Dinner was served at 7

p. m., with dancing and vaudeville acts until midnight. It is superfluous, perhaps, to mention that no business was transacted.

The affair was held in the ballroom of the Elks Club, which affords the best accommodations in Los Angeles for such an occasion. Music was furnished by a locally celebrated seven-piece orchestra. The special vaudeville acts were provided through the courtesy of six local motor-vehicle, tire, oil and brake-lining companies.

Besides the special printed program, a unique menu of the dinner was issued in the form of a blueprint, hand lettered and illustrated with drawings, very free-hand. It showed the courses from tomato surprise "a la Ricardo" to demitasse, "aviation grade."

Sales Talk to Body Men

Chamberlain Addresses Enthusiastic Meeting of Detroit Section Body Division on Car Salability

THE Body Division of the Detroit Section celebrated the first anniversary of its birth on March 25 by a very enthusiastic meeting at the Book-Cadillac, attended by more than 600 members and guests. A paper on This Body Business, by R. C. Chamberlain, general sales manager of the Packard Motor Car Co., was well received. Walter T. Fishleigh, Past Chairman of the Detroit Section, presided, and guests at the speakers' table included Alvan Macauley, president, C. W. Perry, treasurer, and H. W. Peters, director of sales, of the Packard Company; C. W. Avery, president of the Murray Corp. of America; H. Stephens, sales manager of the Cadillac Motor Car Co.; Mr. Valpey, sales manager of the Graham-Paige Motor Corp.; Mr. Hoagland, president of the Hayes Body Corp.; and R. E. Sheahan, sales manager of the United States Rubber Co.

Some humor was mixed with much serious comment on the body business by Mr. Chamberlain, who said that to obtain some ideas of a humorous nature to relieve the monotony of a serious discourse, he asked for the assistance of a body engineer, but that after thinking it over for a day or two the man confessed that he failed to see anything funny about the body business. There was something funny, however, said Mr. Chamberlain, about his talking to a gathering of body engineers, because all car salesmen, including himself, have at times said many uncomplimentary things about them. Engineers have been trying, ever since he can remember, to get salesmen to sell what they design, and salesmen have been trying to get engineers to design what they could sell. The difficulty has been to get engineers and salesmen close enough together in ideas so that the result would represent a product that could be sold. This was the theme of the speaker's whole address.

New General Motors Research Laboratories Building Where Detroit Section Meeting Was Held

Certainly the industry has prospered with the designs produced, but whether the designs had a very appreciable effect on this prosperity is not so certain. To illustrate, Mr. Chamberlain told of a man he knew who was much worried because he weighed 325 lb. He consulted his physician and was advised to smoke. After doing so for a month, he told the doctor that the prescription was no good, as he still weighed the same. "Continue to smoke anyway," replied the doctor, "because you don't know what you would have weighed now if you had not smoked." Similarly, engineers do not know how much better the automobile industry might have been if it had not been for their engineering.

Body Engineer Takes the Lead

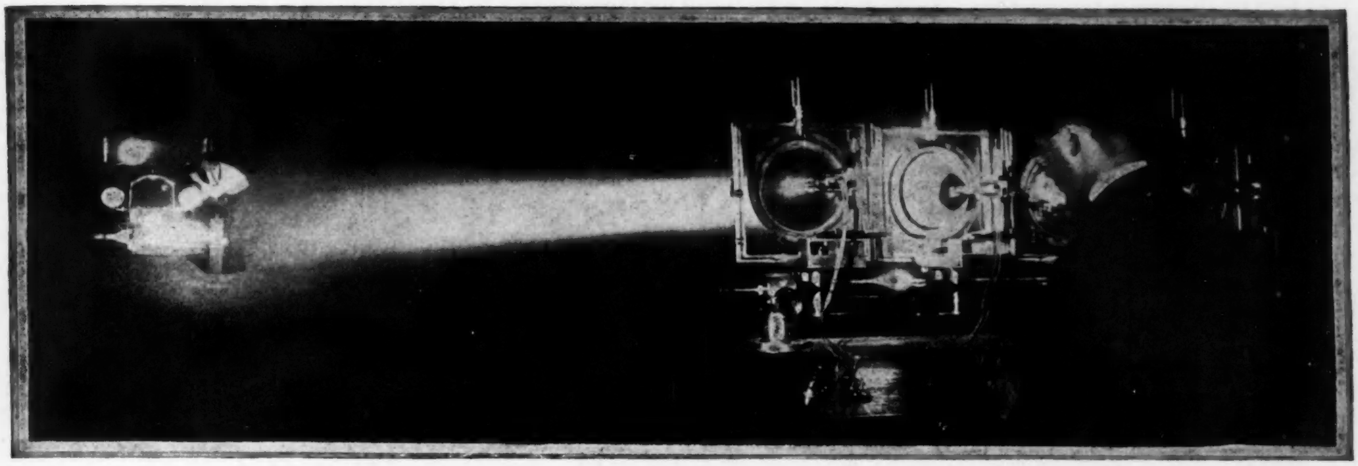
Good natured criticism was directed against engineers who have gained great prominence by making motorcars mechanically satisfactory and, becoming chief engineers in a huge industry, shunned those who mix with the "common herd." When it became evident that some engineering brains was required in the body end of the business, they turned a cold shoulder on the idea, and only at the insistence of management grudgingly appointed underlings to the job of "body engineer." Today, however, the situation is almost reversed, according to Mr. Chamberlain, and the body engineer has become all-important and has made it well-nigh impossible for the chassis engineers to keep pace with him.

Because the chassis of cars within a price class are mechanically so uniformly good and the prices are so nearly alike today, other factors are having more influence on sales than ever before. Under these conditions no one will discount the importance of body engineering. First in its importance the speaker placed beauty of appearance; next, physical comfort, actual and psychological. In a sense, our present car is modern exteriorly but antique inside. Is it not possible, asked Mr. Chamberlain, that there has been too little blending of exteriors and interiors, so that the whole can represent a complete unified design?

Customer Must Be Pleased

In the last analysis, it is the customer who must be pleased, and it is the duty of our industry to combine and direct its energies—engineering, producing and selling—to give the buyer a serviceable vehicle possessing such characteristics as he wants.

Used cars in the market are the limiting factor in new-car selling. In this connection, the thought occurs that the bodies were not sufficiently well engineered to have a life equaling that of the chassis. At the same time, style has changed rapidly, with the result that car owners have been trading-in their



DEVELOPING HEAD-LAMPS IN A DARK ROOM AT GENERAL MOTORS LABORATORIES

automobiles at a time when it was necessary to take an excessively heavy depreciation, and the dealers have been forced to allow more for the used cars than they would bring in the market.

SUGGESTIONS THAT WILL HELP

The industry is confronted with an exceedingly difficult problem. Obviously, the first thing to do is to find out exactly what is needed, which is the task of the distribution department. It is a huge task, as only by the most careful scrutiny of the tendencies of style can a safe conclusion be reached. Benjamin Franklin gave sage advice when he said, "Never be the first to take up a new fad, nor the last to drop an old one."

Mr. Chamberlain offered body engineers four suggestions that he believes will be of help to them, as follows:

(1) Secure a proper understanding of the importance of your work on the part of engineering, distribution and management

(2) Promote the highest possible degree of cooperative spirit between yourselves and these departments

(3) Submerge your own likes and dislikes and endeavor to determine as exactly as possible what is wanted by the customer

(4) Put tradition into the background and strive for the utilitarian, the comfortable, and the beautiful.

Northern California Studies Engine Design

DEVELOPMENT of an engine design that would enable a trained crew of workmen to make all repairs, except those to main-bearings, in a maximum of 2 hr., if the engine does not need to be removed from the chassis, was described by E. J. Hall, vice-president of the Hall-Scott Motor Car Co., of Berkeley, Cal., at the meeting of the Northern California Section held March 14, at the Engineers Club, San Francisco. Experience has shown, he said, that it is much better not to take an engine out of the chassis if repairs can be made while the engine is in place.

Numerous lantern slides of the principal parts of the engine described were shown by Mr. Hall, who explained in detail the advantageous features incorporated in the design. He called attention to the interchangeability of the cylinder-blocks and other parts, and explained the pressure-feed lubricating system, the means used for filtering the oil, and other features. Slides were also shown illustrating the removal, repair, and replacement of various parts such as pistons and connecting-rods.

The meeting was attended by 109 members and guests. Chairman S. B. Shaw presided. At the brief business session, H. L. Miller described the plans for the meeting of the Section to be held April 13 at the Oakland, Cal., airport, where the afternoon will be devoted to demonstrations of airplanes. A banquet and the technical session are to be held in the evening. The Nominating Committee named the following members as candidates for Section officers, the election being scheduled for the May meeting: H. L. Hirschler, Chairman; E. H. Zeitfuchs, Vice-Chairman; Howard Baxter, Vice-Chairman for the East Bay section; W. S. Crowell, Secretary; and Fred L. Sargent, Treasurer.

Diesel-Engine Development

Progress at Westinghouse Factory and Stearns Laboratory Recounted to Pennsylvania Section

DIESEL engines held the attention of more than 125 members and guests of the Pennsylvania Section during a long meeting on March 13. The technical session followed a dinner during which the diners enjoyed an entertaining program. The concentration of interest in the subject of Diesel engines in certain plants is indicated by the attendance of a score or more men from the Westinghouse Electric & Mfg. Co., which furnished the first speaker of the evening, and a similar number from the J. G. Brill Co., which furnished the chairman.

Charles O. Guernsey, who presided, made the arrangements for this meeting, at which the speakers were D. W. R. Morgan, manager of the internal-combustion-engineering department of the Westinghouse company, and E. A. Canning, chief engineer of the F. B. Stearns Laboratory, which is maintained in Cleveland by the founder of the F. B. Stearns Co. At the request of Section Chairman Gelpke, Mr. Guernsey reported on the meetings of the Sections Committee of the Society during the Annual Meeting in Detroit.

In opening his address, Mr. Morgan commented on the willingness of those engaged in the development of oil engines to share their information for the general good. This spirit helps progress. Development of the oil engine, he said, should tend toward a further reduction in weight and size such as has already been attained chiefly through increased speed and advances in metallurgy. The progress that has been made was demonstrated by several scale models of representative engines of different dates, including a 1340-hp., 125-r.p.m. Burmeister & Wain engine, a 900-hp. submarine engine, and a smaller 1340-hp., 800-r.p.m. engine

developing approximately 79 lb. brake mean effective pressure. Only the last of these is small enough to go inside the locomotive cab, a model of which was also shown.

Post-War Development Outlined

The Westinghouse company developed an experimental two-cycle oil engine in 1915, said Mr. Morgan, but work upon it was abandoned during the war. In 1922, a six-cylinder two-cycle opposed-piston air-injection engine was built at the South Philadelphia works and installed in the powerhouse. This develops 650 hp., operates at 500 r.p.m., and weighs approximately 100 lb. per hp.

More recently, an experimental single-cylinder two-cycle opposed-piston engine was built, and a 12-cylinder engine developed from data secured with this. This engine is built in the form of a square, with cylinders on four sides and a crankshaft at each corner. A generator is enclosed mostly inside the engine driven from the crankshafts by idler gears.

Four-cycle engines also have been built by the Westinghouse company, beginning with designs developed by the Beardmore company in England with the aid of a British Air Ministry subsidy, and following with engines such as are used in rail-cars by the J. G. Brill Co. One feature of these engines is that the crankshaft is supported in the crankcase instead of in the bedplate.

Eight holes, each of 0.013-in. diameter. are used in the atomizers of the rail-car engines, and little trouble has been experienced from plugging. A spring is set for approximately 800-lb. pressure, and the lift of the needle is approximately 1/16 in. Adjustments are provided for both the spring tension and the lift.

Trouble with wear of the valve mechanism was found to be because of inadequate oiling, and has been corrected by a provision of force-feed lubrication. Some trouble in fuel-pumps has been overcome by a change in materials, which is effective except in the presence of grit or high-sulphur fuel.

Slides were shown to illustrate many of the engines and their details, including the governors and superchargers. Mr. Morgan recognizes that much research work needs to be done still, particularly to secure better coordination between the fuel-pump and the atomizer.

Laboratory Work in Cleveland

Some of the work of the F. B. Stearns Laboratory was described by E. A. Canning, chief engineer, who began with an outline of various engine-cycles.

For fuel injection, Mr. Canning prefers the common pressure-pipe with spring-loaded needle-valves to control injection. Two fuel-pumps often are used in such a system, and the engine can operate with either of these in case of trouble with one.

The piston is said to be a limiting member of the high-speed Diesel engine. The ideal piston would have no weight and would absorb little heat from combustion; it would have the same coefficient of expansion as cast iron, and tensile strength equal to that of steel. Early injection and high compression are essential for rapid ignition, and they result in pressures of more than 1000 lb. per sq. in., with a temperature of possibly 1800 deg. fahr. Aluminum-alloy pistons have given the best results in Mr. Canning's experiments, but they are limited to a maximum pressure of 750 lb. per sq. in. One of the dangers is that unequal distribution of fuel under full load will cause one of the pistons to be subjected to pressure and temperature beyond the limit of safety.

Present Diesel engines, Mr. Canning feels, cannot compete with gasoline engines in automobiles and motor-trucks, because of economic reasons. The chief fields in which he is interested are locomotive traction, marine auxiliaries, and general industrial work.

Engineers Revising World Affairs

Vivid Picture of Effects of Mechanical Development Painted by Stout at Detroit Ladies' Night

Unusually large attendance marked the meeting of the Detroit Section Aeronautic Division at the Hotel Book-Cadillac on Feb. 25, when Ladies' Night was celebrated and an informal dance for which music was furnished by the Detroit "High Hats" followed a spirited talk by William B. Stout, of the William B. Stout Engineering & Finance Co. Section Chairman B. J. Lemon opened the meeting with a whimsical address, in the course of which he pointed out how the mechanics of the modern airplane is founded upon research and experimental work of the physicists of earliest times.

After dwelling upon the part played by flying-machines in the World War, Chairman Lemon introduced Dr. Andrei Poprovics, Secretary of the Roumanian Legation in the City of Washington, who voiced the thanks of his nation and government for the aid rendered it by America during and after the war, and then decorated with the Order of the Court of Roumania. in the degree of Commander, Harold H. Emmons, now of the Detroit Motorbus Co., who had been prominently active in airplane-engine production during the war.

In accepting that distinction, Mr. Emmons paid a graceful tribute to the Roumanian nation and its history, reviewing it briefly from the early invasion by the Romans down to that by the Central Powers. Giving due credit to the organizations and men engaged in aviation-engine building in war days, he told of the ways in which more than 30,000 such powerplants were completed in America prior to the cessation of hostilities, and he modestly minimized his own share in that achievement.

Chairman Lemon announced to the members and their ladies the presence of many notabilities at the meeting, including representatives of the University of Michigan Alumni, Detroit Bar Association, National Defense Committee of the Board of Commerce, Cadillac Post of the American Legion, and the Consular Service of Detroit. After presenting William C. Naylor, of the William B. Stout Engineering & Finance Co., who had arranged the evening's program, Chairman Lemon turned the meeting over to Capt. L. M. Woolson, of the Packard Motor Car Co., Chairman of the Section's Aeronautic Division. Captain Woolson then introduced the following members and guests to the meeting; Major Royce, U. S. A., commander of the First Pursuit Group, Selfridge Field; Edward S. Evans, director of the Aeronautical Chamber of Commerce of the United States and founder of the Glider Club for promoting motorless flight among the youth of this Country; Captain Sine, Air Officer of the 65th Division Reserve Organization; Major Hinkle, formerly of the Lafayette Escadrille; President Utly, of the Detroit Board of Commerce; William R. Strickland, President of the Society; Mrs. M. Blackburn, president of the Women's Aeronautical Association; Edward Stinson, founder of the Stinson Aircraft Co.; Mr. Burnett, who is now building an all-metal-clad airship, and William B. Stout, the speaker of the evening.

New Foundation of Wealth

As usual, Mr. Stout's talk bristled with both facts and humor. He dwelt on the change of tempo in modern evolution. Within the last 25 years, he said, we have accumulated a tremendous mass of facts in every branch of industry, until, particularly within the last two years, we have come to a point where the precedent of anything more than 10 years back is of little value. The world changes more in one year today than it changed in the entire lifetime of our fathers; and if we

believe a year from now what we believe today, we are slipping.

The approaching day of the research engineer as an executive is bringing a tremendous revision in world affairs, according to Mr. Stout. What is the economics of this new condition? he asked; and, answering himself, said that in the old times we thought the basis of wealth was money, but we have come to a system of economics in which we know that the foundation of wealth is only the production of goods. We have developed new industries that are recreating man himself, changing his very fundamentals of thought and living.

Mr. Stout pointed to the raising of the standard of living enjoyed by the low-intelligence worker, through the possibilities offered by present-day machine civilization, and to the solving by mechanical means of personal problems that we have tried to bring about by ethics. For example, we have been trying to bring about an international language but have not yet succeeded; but we are going to have one, and it will be the language in which the best radio programs are given.

Good-Will Mission of Aviation

Similarly, the aviation industry has a mission to mankind that nothing can duplicate, which is to bring the nations together into an understanding that will eliminate war through the natural mechanical solution of the problem. Aviation will bind the European nations together, he explained, by virtually eliminating boundaries. No man in the world has enough imagination even to guess one-tenth of the development that will be made in five years. Mr. Stout visualized airports everywhere, equipped with hotels and restaurants to serve the airplane passengers, and prophesied that air travel shortly will become an everyday matter.

The aviation engine has been revolutionized in the last few years, but its design will be changed even more during the next five years, not only by the production of Diesel types, but by other new types now appearing on the horizon. Mr. Stout also foreshadowed the use of new metals that are lighter and stronger than any now used, and revolutionary changes to be anticipated in fuels and their combustion.

Through the agency of the airplane, the speaker said he expects an even greater revision of our civilization than the automobile has accomplished. Instead of 30, we shall be able to live 100 or 150 miles from the city in which we work. The revolution forced by new transportation methods will come not only in aviation but in every branch of industry. Development of the radio and its use will play an essential part in this process, to the end of directing airplanes and enabling occupants to communicate with persons on the ground.

Lubricants and Lubrication

Northwest Section Dinner, Entertainment and Addresses on a Subject of Wide Interest

FIFTY members and guests of the Northwest Section, meeting at the Bergonian Hotel in Seattle on March 16, had a most enjoyable and instructive evening. The dinner preceding the technical session was featured by orchestral music and songs and dances by two juveniles and a son of Ham. After Chairman Robert S. Taylor convened the meeting, Vice-Chairman A. R. Trombly reported on the February meeting in Portland, Ore., and Secretary A. M. Jones announced plans for the next meeting, to be held in Portland on April 20, at which C. C. Humber is to give an address on Motorcoach Maintenance. The Section now has 120 registered members, he said, and the Membership Committee is actively trying to develop a student membership.

The principal speaker at the Seattle meeting in March was E. S. Evans, of the engineering department of the Standard Oil Co. of California, who spoke at length and most entertainingly and informatively of petroleum lubricants and lubrication. F. W. Webb, northwestern director of the Fisher Body Corp., was introduced by Valentine Gephart and recounted briefly a little of the development of the company with which he has been connected for about 25 years, citing an instance of cutting the waste down by 17 per cent in the early days after traveling about the Country for about six months investigating methods. Chairman Taylor supplemented Mr. Webb's remarks by stating that some of the Fisher body work is to be done in the Northwest, it being Mr. Webb's present job to show that the company would save money by having some of the material fabricated there and shipped to the company's various plants in the Country.

Combustion-Chamber Oil Control

The next speaker was Hugh Swartz, who presented a short paper describing a unique method of oil control on combustion-chamber lubrication. Exhaustive tests over a period of time under actual working conditions have proved, he said, that a small quantity of slow-burning non-carbonizing oil introduced into the combustion-chamber of an internal-combustion engine tends to reduce the accumulation of hard deposits of carbon and at the same time makes it possible for a small quantity of oil to reach the extreme top of the combustion-chamber walls, the valves and the valve-guides.

Briefly, the device for accomplishing these results automatically controls the flow of oil from the lubricator by means of a vacuum regulator incorporated in the line leading from the inlet manifold to the dash control and adjusted to admit air whenever the vacuum set up in the line exceeds 2 in. of mercury. From 1½ to 2 in. of vacuum furnishes enough energy to maintain a constant flow of oil. When the vacuum exceeds this, a thin copper disc on the regulator is automatically depressed sufficiently to admit enough air to restore the vacuum to 2 in. of mercury and so maintain a constant oil-flow to the oil-control valve on the dash. Regardless of the varying speeds of the engine, this constant vacuum gives a fixed and constant supply of oil to deliver to the inlet manifold. When the engine is generating less than the predetermined vacuum, the oil ceases to flow but instantly recommences when the 2 in. of depression is reestablished.

A demonstration of the operation of the device was made with a small model by Mr. Warren at the conclusion of Mr. Swartz's description.

Comprehensive Discourse on Oils

Four reasons for putting lubricating oil into the crankcase of an engine were listed by Mr. Evans as: (*a*) to minimize friction and wear, (*b*) to absorb and dissipate heat, (*c*) to serve as a piston seal, and (*d*) to act as a cushion for deadening noise of moving parts, as the transmission and differential gears.

Friction is very desirable, in some cases. If a lubricant could and did eliminate all friction, said Mr. Evans, we should have perpetual motion. If it were not for friction we would be unable to stop our automobiles by means of brakes. Dry friction and fluid friction were discussed, and the nature and uses of fluid lubricating oil, semi-fluid grease, and so-called solid lubricants such as graphite, talc and mica were mentioned. Strictly speaking, the greases and solids are not lubricants at all, he asserted, although under certain conditions they serve to reduce friction. The speaker then went on to tell of the kinds of lubricant that should be used in the automobile engine, the transmission, universal-joints, and the differential, emphasizing that none but a perfectly fluid oil should be used in a worm-drive rear axle if lubrication troubles are to be avoided. To avoid leakage from the transmission case,

it is sometimes necessary to use grease rather than oil. The grease does not make gear shifting harder in cold weather, as does heavy oil, because grease has the property of shearing when the gears are first moved, and further motion is relatively much easier than in the case of thick oil.

Oil Not a Metal Substitute

Various systems of engine and chassis lubrication were referred to briefly, and the speaker then reviewed the history of the petroleum industry, methods of refining, oil testing, oil dilution and contamination, the use of air-cleaners and oil-filters, and crankcase ventilation. Mr. Evans spoke of the need for intelligent selection of oils for specific uses according to their properties, and emphasized the importance of using an oil of just the correct viscosity so as to get the maximum mileage per gallon of fuel. He cautioned particularly against the tendency to use an excessively heavy oil after a car or truck has been run for several years and shows signs of wear by increased oil consumption. By using a heavier oil, the operator is trying to correct one factor that has changed while other factors remain unchanged. Clearance between piston and cylinder-wall remains approximately the same, the piston speed is unchanged, the lubrication system is the same, and so is the metallurgy of the engine parts. The operating temperature is somewhat less than when the engine is new, because the bearing surfaces are smoother. Therefore, instead of using a heavier oil, it is cheaper to correct the fault by mechanical means, as oil cannot be used as a substitute for mechanical parts.

In conclusion, Mr. Evans attempted to correct misapprehension regarding the comparative qualities of oils made from eastern and western crudes, pointing out that many oil wells in different parts of California are producing some of the purest paraffin-base crudes to be found, while wells a few miles from them are producing naphthenic-base oils. If it were true, as some claim, that western oils break down faster than eastern oils, the Pacific Coast would have a large supply of cracked gasoline and the East would have virtually no cracked gasoline, a condition that is contrary to the facts. It is not a fact, either, he said, that western oil thins out faster than the finest paraffin-base oil. To substantiate these statements, he invited his hearers to witness demonstration tests at some time with a portable machine and, at the conclusion of his address, ran off a reel of motion pictures.

The Flat-Rate System

New England Section Told Details of How the Repair Price Method Is Applied

CHARGING a flat price for repairs was the subject presented and discussed at the meeting of the New England Section held March 20. The dinner was attended by 54 members and guests, and 120 were present when Chairman George L. Appleyard convened the technical session.

In his paper on the flat-rate system, Frank E. H. Johnson, of the Noyes Buick Co., of Boston, reviewed previous conditions in the service field with regard to charges for repair work and said in part that the flat-rate or definite-price system of charging calls for the elimination of charges made on the basis of time and material. It establishes a fixed price for each operation, and each customer pays that price for that particular job. Each workman knows beforehand what he will receive for performing his work. The repair shop buys its labor as merchandise at a fixed price and sells it at a fixed higher price, the difference being gross profit.

The incentive that the system provides is the possibility for the mechanics to make the greatest amount of money in the shortest possible time. The more skillful mechanics make the most money, produce the most work and bring in the greatest possible profit in the least time. All work is guaranteed by the mechanic to be satisfactory to the customer.

System Based on Time-Study

Since, in the flat-rate system, time is the foundation upon which piece work and customers' charges are based, it is essential that the time element be determined accurately for each operation as performed in the average shop, under average conditions by average mechanics. If, as each operation is performed, a record is kept of the actual elapsed time, it is possible, said Mr. Johnson, to compare results from many shops and many men and to obtain cost data which are fair to the customer, to the shop and to the mechanic. Being based upon the law of averages, the system is in the long run fair and satisfactory to all concerned.

Mr. Johnson divided labor into two classes, productive and non-productive. The former is that which is either sold direct or produces articles which can be sold; therefore, repair-shop mechanics and the men who make the parts or assemble cars are included in this class. The non-productive labor includes that of the executives of the organization and all miscellaneous labor for which no direct charge can be made; and salaries and wages paid for all such labor are classed as "expense," which includes also money paid for rent, heat, light, power, and the like. All expense items, including non-productive labor, combine to constitute what is called "overhead."

It was said also by Mr. Johnson that it is possible to calculate the total overhead cost with fair accuracy and, knowing the cost of productive labor, to express the overhead as a percentage of the productive-labor cost. It is necessary to charge expense as well as productive labor to the customer, and to add a reasonable amount for profit. This accounts for the wide difference between the pay of the mechanics and the charges to the customer. The charge to the customer is computed by multiplying the mechanics' actual average by a factor large enough to include labor, overhead and profit. The mechanic's pay is calculated by multiplying the mechanic's actual time by a fixed rate per hour.

Distribution of a Charge

The distribution of expense for a so-called $10 job, said Mr. Johnson, would be approximately as follows:

	Expense	Per Cent
Mechanic's Pay	$3.50	35.0
Inspector, for Selling and Testing	0.47	4.7
Superintendent	0.35	3.5
Shop Supervision	0.30	3.0
Office Salaries	0.20	2.0
Miscellaneous Non-Productive Shop-Labor	0.20	2.0
Policy Account	0.05	0.5
Power and Light	0.05	0.5
Rent	1.00	10.0
Telephone and Telegraph	0.03	0.3
All Other Overhead Expense	2.34	23.4
	8.49	84.9
Net Profit	1.51	15.1
	$10.00	100.0

Mr. Johnson gave details of how trouble is diagnosed, and one of the system of records on which the costs of the work are entered and followed through. He showed interesting lantern slides of the service stations and repair shops of former days, and compared these with illustrations of strictly modern service stations and shops. He also analyzed the objections that have been made to the flat-rate system.

Details of Application Discussed

Many questions were asked and answered during the progress of the animated discussion which followed the presentation of the paper. These related largely to details of making proper distribution of the charges, to securing the cooperation of the mechan-

ics, and to keeping records. Capt. Walter C. Thee, U. S. A., described the practice of the Army with regard to the engine-repair section in the First Corps area, Boston.

C. C. Lawton, of the Worcester Buick Co., said that he favors the flat-rate system and that it has eliminated about 90 per cent of the complaints of customers with regard to the prices charged them.

Glenn S. Whitham, of the Charles Street Garage, Boston, expressed the opinion that the flat-rate system has done more for both the car owners and the repair-shop owners than has any previous innovation in the service industry. He said further that the flat-rate system satisfies the desire a man has to go into business for himself, because it practically makes a contractor of him. It is a means and provides a plan for the establishment of the highest form of shop equipment, and for compensating for the tool equipment out of the earnings.

Air and Ground Transport

Woolson Pictures Effect of Aviation on City Location and Development at Cleveland Meeting

VISIONS of the effect of aviation on the future location and planning of cities were presented graphically by word and chart before a gathering of about 150 members and guests at the Cleveland Section meeting on March 11 by L. M. Woolson, of the Packard Motor Car Co. Chairman Ferdinand Jehle presided. Following a Southern chicken dinner and a Southern entertainment, the technical session was opened by the introduction of Capt. H. C. Richardson as the man who really made the first transatlantic flight, in 1919. In responding, Captain Richardson announced that he is to retire from Naval service on May 1 and join the Great Lakes Aircraft Corp. in Cleveland.

Chairman Jehle then announced that the April meeting of the Section is to be a ladies' night affair, with a good dinner, the Detroit "High-Hat" orchestra and a big attendance.

Automobile Engineer's Part

Captain Woolson, in his prepared paper, referred to the present interest of the automobile industry in the possibilities in the aircraft field and suggested that it is time for the automobile engineers to give serious thought to the part they may be expected to play in aeronautics. Aviation has reached its present stage of development, he said, without the benefits of low costs associated with large-scale production or of airport construction on a scale comparable with the great strides made in highway improvement that has contributed so much to the growth of the automobile industry. What effect on the aircraft industry similar advantages would have was indicated by the statement that one year's average expenditure of $1,000,000,000 on highways would build not less than 200 first-class, completely equipped airports.

The need for centrally located airports in our cities was mentioned, and a slide was projected on the screen to show a novel conception of the future layout of a city based on transportation by air as well as by rail, water and highway, with an airport in the center of the city.

Developments Due to Airplane

Referring to the effect of water and rail transport on the location and growth of cities, the speaker visioned the corresponding effect of air transport, and as examples mentioned the importance of Wichita, Kan., as an aircraft center because of the flat terrain and the favorable atmospheric conditions; of California as a region of airplane use; and of Columbus, Ohio; Dodge City, Iowa; and Las Vegas, Nev., as transfer points on the air-rail transcontinental route.

If the present rate of increase is maintained, 1,500,000 airplanes will be in use in this Country in seven years, which does not seem an extravagant prediction, said Captain Woolson. The one cloud on aviation's otherwise bright horizon, speaking both metaphorically and literally, he said, is the problem of flying under conditions of poor visibility. In addition to efforts that will be focused by cities on the smoke nuisance, the speaker mentioned as factors that will tend to improve conditions, (*a*) electrification of railroads, (*b*) more extensive use of oil-burning equipment, (*c*) general substitution of central heating and lighting plants for isolated equipment, and (*d*) increased use of smoke-consuming devices.

The speaker next discussed at length airplane design as a field as yet unexplored by the motor-vehicle design engineer, who is, however, particularly well fitted to bring about cost reduction by methods applied to the automobile and truck industry. And finally he presented comparative statistics and charts of operating efficiencies of various forms of transportation by air, land and water. From these he deduced that little possibility exists of the airplane ever competing with either the railroad or the motor-truck as a freight carrier; that it is reasonable to expect more extensive use of the airplane for carrying express matter and valuable goods; and that for passenger traffic a very bright future for virtually universal adoption of air transport is indicated.

Diesel Engine Increases Radius

Discussion following presentation of the paper mainly concerned the new Packard Diesel engine and the operation of an airplane with the heavy-oil engine. Edward Wallace, of the Great Lakes Aircraft Co., inquired if Captain Woolson had any figures on the performance of buoyant airships propelled by Diesel engines as compared with gasoline engines. In response, Captain Woolson said that Carl Fritchie, of the Aircraft Development Corp., who has written a good paper on the subject, has shown that, on a basis of specific fuel consumption, a Diesel-engined airship could have a cruising radius of 4800 miles as against 4500 miles for a gasoline-engined ship, or the pay-load could be increased in similar proportion.

Asked by P. B. Jackson, of the Aluminum Co. of America, if lower specific weight for the same cruising range can be obtained with a Diesel-engined airplane, considering the combined weight of the powerplant and its fuel, Captain Woolson replied that, on the basis of over-all weight, such an airplane could not compete with the gasoline-engined plane with fuel aboard for only a 2-hr. flight, but that after about 4½ hr. the Diesel-engined plane becomes lighter than the gasoline-engined plane. The assumption, based on many tests, is that an airplane carrying six passengers will fly about 19½ miles per gal. at 90 m.p.h., at a fuel cost of 8 cents per mile if using furnace oil and considerably less if using some of the heavier oils.

Importance of Engine Reliability

Wesley L. Smith, of the National Air Transport, mentioned that in the air-transport business the fuel cost is about 2 per cent of the total cost of operation, and maintenance and upkeep about 20 per cent. Liberty engines are about 200 per cent better, he said, than any engine built since they were brought out; with them, mechanical forced landings occur about once in 200,000 miles, whereas with every other engine such a landing occurs in every 30,000 miles. Maintenance expense, responded Captain Woolson, is purely a matter of development of the engine design, regardless of type of engine. The longer any airplane engine is in production the more nearly perfect it becomes, if the designers try to make it better from the viewpoint of operation in-

stead of trying to get more power out of the engine. The first Liberty engine had plenty of "grief." Development work on it was divided into two classes: research, to get more power; and improvement, to increase reliability. Strength, he said, was never sacrificed to get more power.

Other questions related to Diesel-engine acceleration for takeoff, fire hazard with heavy oil, effect of characteristics of the Diesel engine on relative importance of aircraft performance, reliability and other factors, speed of the engine and its relation to effective propeller speed with direct drive, difficulty from water in the fuel, and whether it is fair to compare a single-Diesel-engined airplane with a three-gasoline-engined plane. Most of these points were covered in the paper presented by Captain Woolson at the Aeronautic Meeting in Chicago last December and published in the February issue of the S.A.E. JOURNAL, beginning on p. 173.

Spectrograph Analysis Outlined

Chicago Section Told of Clark's Previous Work and Its Present Application to Industry

COMBUSTION, explosion and detonation are clearly distinguished by the spectra of radiation in the ultraviolet, said H. A. Smith, research assistant at the University of Illinois, in prefacing his reading of a paper on Spectrographic Studies of Tetraethyl Lead in Gasoline, by Dr. George L. Clark, of the University, at the meeting of the Chicago Section held March 12 at the City Club. Professor Smith went on to say that in detonation or knock the spectra run down into the ultraviolet as far as 2200 Ångström units.

The second point he mentioned in connection with the radiation theory of detonation is that knock suppressers such as tetraethyl lead absorb radiation in the far ultra-violet and invariably shorten the spectra, while knock inducers tend to accentuate the short-wave radiations. A third point is that radiation accompanying detonation is emitted during virtually the entire first two quarters of the engine stroke; whereas the spectra of the same length and intensity for all four quarters of the stroke occur when the engine is operating without knock in the presence of detonation suppressers. Tetraethyl lead, iodine, and aniline, though differing widely in chemical nature, act alike in this respect.

Completing this summary of the X-ray work that already has been done, Professor Smith stated the fourth point to be that the emission-spectrum lines of lead, which appear when the fuel contains only the slightest trace of tetraethyl lead, are not usually evident after the first quarter of the engine stroke, which indicates that the action of the compound in suppressing detonation occurs very early in the oxidation reaction.

Basis of Spectrographic Analysis

Professor Smith reviewed briefly the work done at the University on the determination of very small quantities of tetraethyl lead in gasoline by means of the spectrograph, and also outlined the instrument's application to industrial problems. He explained that the basis of the method of analysis by spectrograph is that each element excited gives out emissions which correspond to the oscillations of the atom itself. Each of the lines is absolutely characteristic of the element which does the work of emission. For this reason, optical spectrographic analysis is unique because, if there is a line in the spectrum which has been measured, there is no doubt that the element exists, because no other element gives a similar line. In other words, each element has its characteristic emission line. But the problem of quantitative analysis is more difficult and depends upon the number and intensities of the lines in the spectrum.

For purposes of test, the gasoline solutions were made up with a known content of tetraethyl lead. Spectra were taken of these solutions and the resulting plates were used as a standard. In conclusion, Professor Smith showed numerous very interesting lantern slides illustrative of the progress of spectrographic work and its application to industrial purposes.

Thirty members and guests attended the meeting and J. W. Tierney was chairman. A report was made by the committee the Section had appointed to interest the publishers of Chicago newspapers in a plan to improve the municipal airport. This was presented by Edward A. Sipp and included suggestions for methods and procedure. Members elected to constitute the Nominating Committee for officers of the Section were: Harry F. Bryan, John A. Cervenka, John Chucan, F. M. Say and Walter Martins.

Aircraft-Engine Inspection

SOME of his experiences in preparing the airplane engines for Commander Byrd's flight to the North Pole were recounted by T. H. Kinkade at the Feb. 27 meeting of the Washington Section. The speaker, popularly known as "Doc" Kinkade, who was formerly connected with the Wright Aeronautic Corp., but is now sales engineer for the Lycoming Mfg. Co., of Williamsport, Pa., spoke chiefly on Inspection of Aircraft Engines in Production.

The meeting was held at the City Club in Washington, preceded by a members' dinner, and was attended by 40 members, Chairman Thomas Neill presiding. Piano selections and dances by two sisters afforded entertainment during the dinner.

A Section Nominating Committee was elected at a short business session.

Fire Engine Progress

Charles Fox Reviews History and Tells Dayton Section About Modern Pumping Engines

METHODS and equipment for fire fighting from the days of the bucket line to those of the self-propelled internal-combustion-engine pumping fire-engine were interestingly reviewed by Charles Fox, president and general manager of the Ahrens-Fox Fire Engine Co., at the March 19 meeting of the Dayton Section. The meeting was held at the Engineers Club following a members' dinner.

Following the advent of the motor-vehicle, the possibility of dispensing with horses used for drawing steam fire-engines was envisaged but the reliability of the steam engines was high and men conversant with the engineering problems were less sanguine about the prospect of gasoline-engine-powered equipment than were novices, said Mr. Fox. It developed that the margins of safety allowed against rupture had to be gaged largely by abuses of the mechanism by the "runners."

Modern fire-apparatus units have many features in common with conventional motor-vehicle practice but perform functions in no wise parallel to those of the ordinary motor-vehicle. Motorization of fire departments began in a rather desultory way about 1910, and in time gasoline-powered fire-engines "made good," considerably before the fact was conceded by the fire commissioners and chiefs. The way for complete motorization of the fire departments was paved by motor ladder-trucks, hose wagons, chemical engines and the like.

(Continued on p. 449)

Chronicle and Comment

The Detroit Aeronautic Meeting

THE DETROIT Aeronautic Meeting is the first of three National aeronautic conferences to be held during 1929, the second being scheduled for Wichita, Kan., at the time of the Aircraft Show there, which probably will be held the first week in July. The third meeting is scheduled for Aug. 26 to 28, in Cleveland, during the week of the National Air Races. Comparison of the proposed technical programs for the three meetings with the technical program for the single aeronautic meeting of two or three years ago is indicative of the way in which the phenomenal growth of the aeronautic industry has been reflected in technical aeronautical discussions.

The program for Detroit, which was announced in a special bulletin sent to the members on March 23, well warrants the attendance of every aeronautical engineer; and the fact that the meeting is to be held during the Detroit Aircraft Show is an added reason for expecting excellent attendance. The Aeronautic Committee, under the chairmanship of Capt. E. S. Land, of the Guggenheim Fund for the Promotion of Aeronautics, and Capt. L. M. Woolson, Chairman of the Detroit Section Aeronautic Division, are to be congratulated on the program, which is interesting not only to aeronautic engineers but also to automotive engineers not now directly connected with the aeronautic industry.

It has been the intent of the Aeronautic Committee to schedule only papers reporting advances in the aeronautic art. Papers reviewing aeronautic developments or discussing aeronautic topics generally are given no place on the programs of the National Aeronautic Meetings. Arrangements are made, when desired, for the presentation of such papers at Section meetings.

Cooperation with Motorboat Industry

CHAIRMAN Dresser, of the Metropolitan Section, expressed the hope at the March meeting of that Section, that by the time the next season is half over the Metropolitan Section will have the first Marine Engineering Division in the Society formed and going. The Council has authorized it and the Governing Board of the Section has sanctioned it; all that has held back the work is that the motorboat people have been so busy expanding that they have had no time to give attention to organizing.

There is evidence, however, that the motorboat industry realizes the desirability of cooperation between marine and automobile engineers. Bruno Beckhard, Secretary of the Outboard Motor Contest Board, very frankly invited such cooperation in his paper on Development of the Outboard Engine, published in the March issue of the S.A.E. JOURNAL. And at the March meeting of the Metropolitan Section, Gerald White, former editor of *The Rudder*, but now connected with Fairchild Boats, Inc., asserted that the industry has reached the point where it needs the Society and the Society needs the industry to work with it. If the automobile engineers feel that there is a possibility of cooperating with the motorboat industry, he knows, he said, that the industry is anxious to cooperate. It is growing, it needs engineers in every branch, and if there is any way in which all can help to make the public more boat-minded, yet not less automobile-minded or airplane-minded, it will be appreciated.

Some interesting figures on the present status of the motorboat business are given in the news report of the March meeting of the Metropolitan Section on page 363 of this issue.

Wants Facts for S.A.E. History

A PLEA for contributions of facts and anecdotes regarding the Society is made by Jack French, who wants to write a paper on the history of the S.A.E. for delivery at a meeting of the Southern California Section. His purposes are to familiarize to a greater extent members of his Section and prospective members with the activities and accomplishments of the Society, and to develop more active interest in it. He particularly desires to have the secretaries of other Sections forward to him such interesting facts and anecdotes as they have that will be suitable for such a paper. Data on the organization and activities of the National body can be supplied to him by S.A.E. headquarters.

Responses to Mr. French's request should be mailed direct to J. T. French, Richfield Oil Co., 2545 East 24th Street, Los Angeles.

Research Cooperation Helps Industry

"IT IS just such cooperation as this that is enabling American industry to show its tail-lamp to the rest of the commercial world," remarked B. J. Lemon, Chairman of the Detroit Section, at the March meeting of that Section in the new research laboratories building of the General Motors Corp.

"Organizations like the General Motors Corp., the Chrysler Corp., and others are disclosing facts and services and machines so that organizations like the S.A.E. shall be able to make contact and do better work in the automotive industry than has ever been done in any other industry. I believe that the cooperation of the different units of the motor-car industry is responsible in large measure for the progress it is making."

America has traveled a long way in a short time from the days of secretiveness in industry, when each company believed that it gained an advantage by conducting its operations behind locked doors. Almost from its inception, the automobile industry in this Country has, with few exceptions, operated on the principle of "visitors welcome." The growth and success of the Society are based to a considerable extent on the amazingly free interchange of knowledge gained at great expense by manufacturing organizations in the industry. And the industry itself has prospered wondrously under this broad-minded policy of its leaders.

Relation of Automotive Engineering to Aeronautics[1]

By Henry M. Crane

THERE are now in general use on land, on water and in the air vehicles of transportation of such simple mechanisms that the entire control is safely vested in the hands of one person having little or no technical knowledge. These may properly be defined as automotive vehicles, and their development has been largely due to the development of the internal-combustion engine. Automotive engineering relates to the underlying theory, the practical design and the construction of vehicles of this type.

The field covered ranges from the motorcycle, the motorboat with outboard engine and the baby airplane weighing a few hundred pounds, on the one hand, to the high-speed motorcoach, the rail-car, the fast cruiser and the giant airplane, on the other hand. Successful engineering in each of the three branches is becoming every day more dependent on knowledge gained in the other two fields.

During recent years a better understanding has been had that what is called "engineering" covers a much wider range of human knowledge and thought than was heretofore commonly believed to be the case.

Branches of Automotive Engineering

Engineering begins in research in all possible branches, including the fundamental theory of engines to produce power, the characteristics of all materials of construction and of methods of construction; and of the primary source of power in the form of some type of fuel, together with the theory of combustion. A second branch of engineering is the application of knowledge gained by experience or by research to the actual design of automotive vehicles. A third branch covers methods and details of construction. A fourth deals with the test of the finished design as to performance. A fifth deals with the economic use of the vehicle in actual service; and a sixth, with the maintenance of the vehicle. The last named two branches are so closely related as frequently to be treated as one.

The automotive engineer has a legitimate interest also in features of engineering pertaining to the use of his product in the construction of highways, airports and other utilities. His interest also extends into the production of raw materials and semi-finished and component parts. There are very few materials in commercial production today that are not of actual service and real interest in the building of automotive vehicles.

The power available to drive vehicles was at first small, but with increasing engineering knowledge this has developed to the point where today units of more than 500 hp. are commonplace, both on water and in the air, can be handled even more readily than the much lower-powered machines of ten years ago.

One structure common to all types of automotive vehicle is the powerplant, which today usually is a light, compact engine burning a hydrocarbon fuel, in the form of either a liquid or a gas at atmospheric temperature and pressure. At the moment the fuel almost universally used is a petroleum distillate modified by the addition of other fuels or of substances having a desirable effect on combustion. The enormous demand for liquid fuel for use in motor-car engines has justified the expenditure of huge sums of money to improve refining methods and in research to develop a fuel better adapted to such use. While virtually everything that has been done in the way of research and improved production of fuel has been primarily for motor-car use, a direct benefit has accrued to the two other automotive branches. Although the optimum fuel for aviation use is not the same as that for motor-car use, the two are produced side by side, using knowledge gained in a common field of research. The two elements of major importance in petroleum fuel are volatility and detonating quality. It is interesting to note that the detonating quality first became of obvious importance during the war because of the great increase in aviation, and that the development of antiknock quality and antiknock materials has been carried on since the war largely under the influence of motor-car demand.

Although the radial air-cooled aviation engine of today bears no very close resemblance to the modern motor-car engine, it is constructed almost entirely of materials originally developed for motor-car use and is equipped with magnetos, spark-plugs, carbureters and ball and roller-bearings developed primarily for that field of service. Of course, there are still aviation engines in production and service having a much closer resemblance to the conventional motor-car engine than the radial type just mentioned.

Reciprocal Benefits

Meanwhile, the motor-car industry has benefited in a very direct way from the engineering of aviation engines. Extravagant ratios of stroke to bore proved to be undesirable under the relentless test of a search for power with low weight. The motor-car industry is now benefiting greatly from this knowledge. The motor-car spark-plug is provided with vastly better porcelain today because of knowledge gained during the war in an attempt to meet aviation-engine requirements. Much of the technique in piston-rings, in piston and valve design and in lubrication systems developed in aviation practice has proved of great value in the automotive industry. The very common use of high-chromium exhaust-valve material in motor-cars may

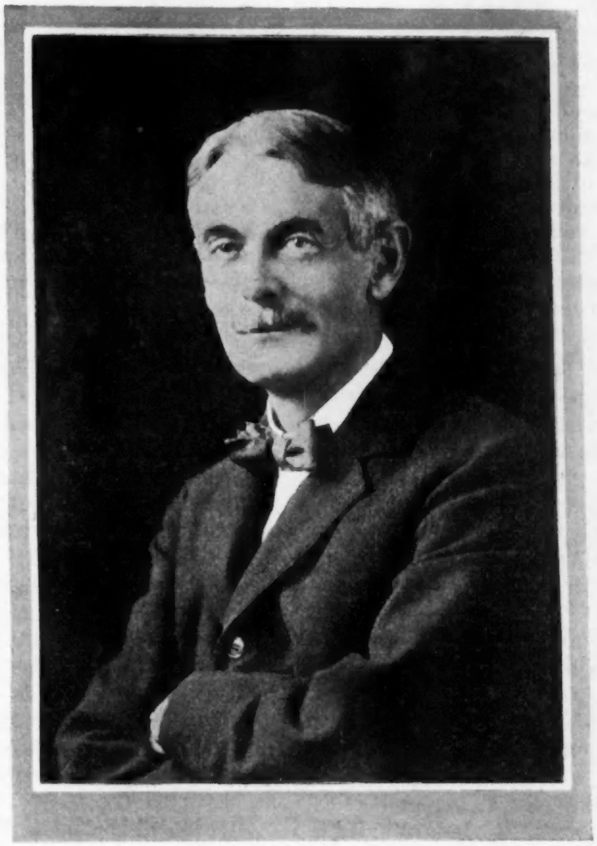
[1] Paper presented at the International Aeronautic Congress in the City of Washington. The author is technical assistant to the president of the General Motors Corp., New York City, and is a Past President of the Society.

be cited as an instance. Supercharging is being developed side by side in motor-car and in airplane engines. The problem of uniform fuel-distribution in multi-cylinder engines is common to all types.

In the motorboat field, virtually all of the larger racing motorboats are powered with aviation engines, while many of the smaller boats use slightly modified motor-car engines. It is perhaps needless to point out that some of the most successful makers of aviation engines were originally producers in the motor-car field. There are, of course, many well-known exceptions but the fact is stated simply to emphasize the extremely close relationship between engineering and production in both branches.

In studying the complete vehicles in the three branches, a marked parallel exists in methods of production, though somewhat less markedly in general design. Twenty-five or 30 years ago, when speeds on the water were usually of the order of 20 m.p.h. or less, and on land 40 m.p.h. or less, the importance of wind-resistance in vehicle design was ignored. Today, however, speeds have advanced to a point that makes a study of wind-resistance of great importance in the economic use of power. As a result, one manufacturer of airplanes is producing motorboat hulls for use with outboard engines, while all the racing motor-cars are designed with the greatest possible attention to air-resistance, often being subjected to wind-tunnel tests. Air resistance has not been treated with sufficient consideration as yet in the design of passenger vehicles, but its importance is gradually becoming recognized.

The high-speed motorboat has been a contributor to aviation engineering in the design of airplane hulls and pontoons. The motor-car has contributed the wire wheel, balloon tire, landing-wheel brake and some forms of spring struts of the shock-absorber type for landing-gears.



HENRY M. CRANE

In production, especially in quantity, the interrelationship between the three types of vehicle is extremely close in spite of their great difference in appearance. The handling of the thin sheet-metal, with fabrication and assemblage by welding or riveting, or otherwise, is of fundamental importance to all branches. Bolts, nuts and rivets are important factors in construction. The motor-car industry was forced to design a new standard in bolts and nuts as an improvement over the old United States standard, which was based on the use of cast iron and mild steel. This standard has proved of value in aircraft construction and the influence of its use in aircraft, by bringing out a product of higher quality, has reacted on the quality now available in the motor-car. Improved methods of measuring thread shape by optical means or otherwise have gone hand in hand with the tap which is ground after hardening and is therefore capable of making a much more accurate product.

One of the most noteworthy advances in the motor-car industry in recent years was the introduction of cellulose-nitrate as an exterior finishing material. The automobile industry owes this advance primarily to the production of various dopes for aviation use.

Among many uninformed people there is a feeling that the motor-car and the airplane are directly competitive and that an advance in one field must be accompanied by a corresponding loss of business in the other field. Nothing could be farther from the truth. Each vehicle is supreme in its own field and the two will progress together, engineering improvement in one industry being promptly reflected by a similar improvement in the companion industry.

The In-Line Air-Cooled Engine

By S. D. Heron[1]

Chicago Aeronautic Meeting Paper — *Illustrated with* Drawings and Photographs

QUOTING a comparison of the radial engine with a star fish, the author compares the frontal areas of radial and V-type engines and shows how air can be applied to the cylinders of in-line engines to secure efficient cooling with minimum parasite drag.

Advantages of upright and inverted engines are contrasted in various respects; and engine-mountings, cylinder design and valve gears are discussed.

Difficulties that have been encountered in gearing in-line engines having less than 12 cylinders are mentioned, and a simple method of gearing is proposed in which the elasticity of a relatively long propeller-shaft is utilized.

The paper concludes with a comparison of the production problems of radial and in-line aircraft engines.

THE time seems to be ripe for discussing the pros and cons of the in-line type of air-cooled aircraft engine. The in-line engine is never likely to be as light as the radial engine unless extremely high rates of revolution become possible, and it is inevitably less compact longitudinally. However, the line type offers the advantage, over the radial type, of considerably smaller frontal area, which probably will result in reduced drag and certainly gives the pilot better forward vision.

In this connection the witty and apt comparison of high-powered V and radial types by C. L. Lawrance may well be quoted: "The passage of a large radial engine through the air resembles that of a starfish through the water, whereas that of the V-type is akin to that of a trout."

It is not generally realized that the first really successful static air-cooled engine was the Renault eight-cylinder V-type. This engine played a very important part in the early development of aviation and established many records, including the winning of the Michelin Cup in 1910 by a non-stop flight of nearly 8 hr.

Since 1916, however, the in-line type has received but little attention, despite the facts that at that time geared V-type engines were available in small quantity with cylinder cooling superior to that of many modern radial engines and that it was not until after the war that equally good radial engines became available. The neglect of the in-line type is to some degree a matter of fashion; further, its method of cooling is much less obvious than that of a radial. In England, development was dropped in 1916 in favor of radials which, while supposedly air-cooled, in reality obtained most of the little cooling they had from excessive consumption of fuel and oil.

Air-Cooled Liberty Built in 1924

The first modern in-line air-cooled engine was the air-cooled Liberty, built at McCook Field in 1924, which served to show what could be done with a high-powered line engine that was compact, at least as regards the cylinders and their spacing. The Cirrus engine, designed in England by Major Halford and built by the Aircraft Disposal Co., Ltd., was the first post-war line engine to attain any considerable popularity. It has come into wide use in England and elsewhere and has given remarkable performances in Moth and Avian airplanes.

The purpose of this paper is not to disparage the radial engine, to which, after all, the modern popularity of the air-cooled engine is due, but rather to call attention to the possibilities of the line type which are at present largely neglected, with the result that thought is almost entirely and somewhat slavishly concentrated on the radial type.

Despite a consensus of opinion to the contrary, the author feels that it is much easier to design and construct a good in-line air-cooled engine than a good engine of the radial type. The mechanical problems of the line type are much simpler, and the cooling is at least as easy; furthermore, the line type renders available to a considerable degree the vast accumulated design and manufacturing technique of the American motor-car industry.

The problems of the line type are dealt with in order of the common consideration of their apparent difficulty.

The line type, as considered in this paper, is confined to four and six-cylinder in-line types and V types having not more than two banks of cylinders.

It is desired to emphasize that the views expressed in this paper are those of the author and may or may not be in agreement with the opinions and policies of the Materiel Division of the Air Corps, to which the author is indebted for permission to use data, drawings, and the like.

Methods of Air-Cooling

All efficient methods of air-cooling line-type engines are direct descendants of that used on the Renault V, an exact duplicate of which, as regards method of cooling for tractor installations, is shown in Fig. 1, which illustrates the R.A.E. 1B, a war-time British engine. In some fairly recent installations of in-line four-cylinder engines, no cowling has been used to direct the air around the cylinders, which are completely exposed to the slipstream without provision for cross-flow. Thus, except for cross-flow due to rotation of the slipstream, only the front half of the front cylinder is subject to anything like adequate airflow

[1] M.S.A.E.—Mechanical engineer, powerplant branch, Materiel Division, Air Corps, U.S.A., Wright Field, Dayton, Ohio.

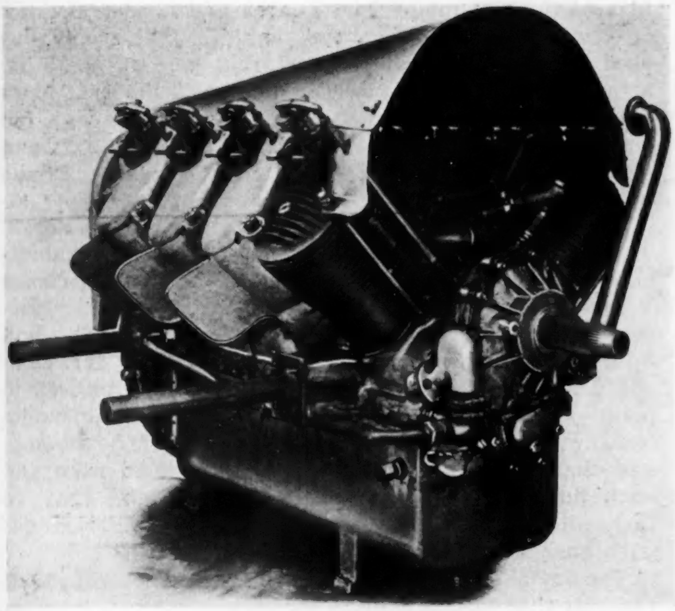


FIG. 1—BRITISH WAR-TIME ENGINE, R.A.E. 1B

The Method of Cooling Duplicates That of the Renault Engine Which Established a Non-Stop Flight Record of Nearly 8 Hr. in 1910

conditions. It says much for the line type that engines so cooled, or not cooled, apparently gave satisfaction. Such methods of cooling line engines, which are somewhat analogous to a multicylinder water-cooled engine with water in only one cylinder-jacket, are still proposed occasionally by those to whom any sheet-metal cowling is apparently anathema. It is worthy of mention that cowling installations producing cross-flow of air around the cylinders are now used for the engines in question.

Digrammatic illustrations of the cross-flow methods of cooling and cowling single-line and V engines are shown in Fig. 2. It may be seen that any air that enters the cowl and thus creates resistance is forced to do useful work in cylinder cooling and cannot escape without so doing; furthermore, all portions of the cylinders are exposed to active airflow and no lee side exists, except such as may occur in the region of the inlet and exhaust ports.

COWLING MAY HELP RADIAL-ENGINE COOLING

Fig. 3 illustrates the condition in the usual radial-engine installation in which the air strikes the front

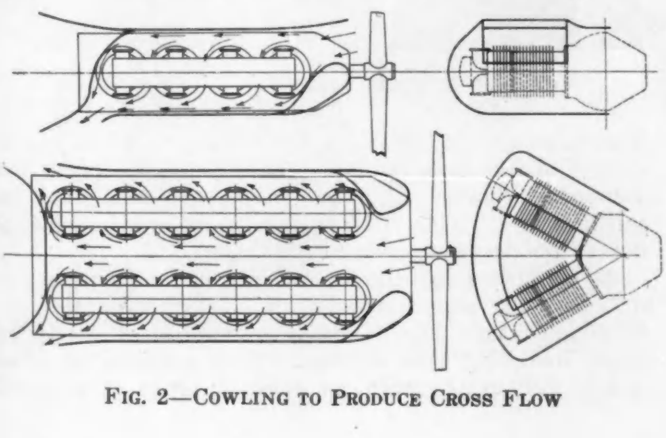


FIG. 2—COWLING TO PRODUCE CROSS FLOW

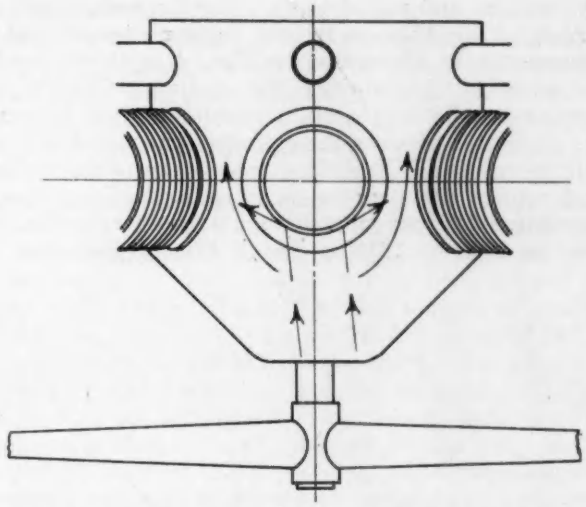


FIG. 3—AIRFLOW IN AN UNCOWLED RADIAL ENGINE

of the cylinders and is, to a considerable degree, diverted into the spaces between the cylinders, partly avoiding the fin cells. This involves a considerable amount of resistance due to interference and disturbance without adequate return in the form of cooling.

While such methods of cooling are common on radial-engine installations, they are anything but essential to the type; the cooling air can be equally usefully used

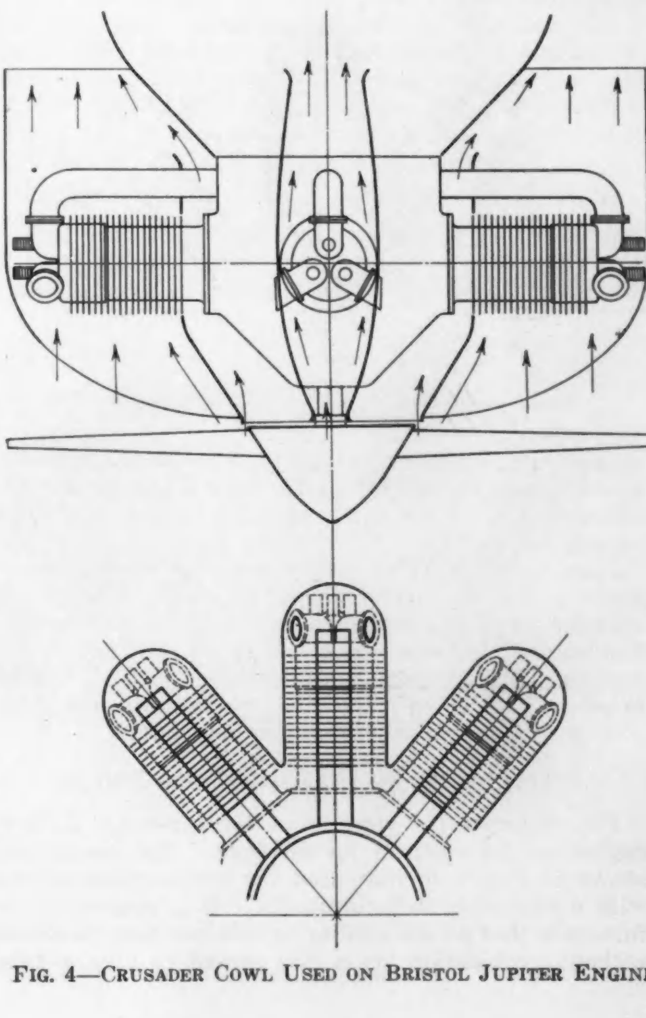


FIG. 4—CRUSADER COWL USED ON BRISTOL JUPITER ENGINE

in both line and radial types. The Crusader cowl, used largely at one time on Bristol Jupiter engines, and diagrammatically illustrated in Fig. 4, actively used all air entering the cowling for cooling. This type of cowling results in a certain amount of interference in the air spaces between the cylinders and is not so applicable to the usual American type of two-valve cylinder with widely tilted valves as it is to the more compact four-valve Jupiter construction. Another method first used in 1918 or 1919 on the B.A.T. airplane and dia-

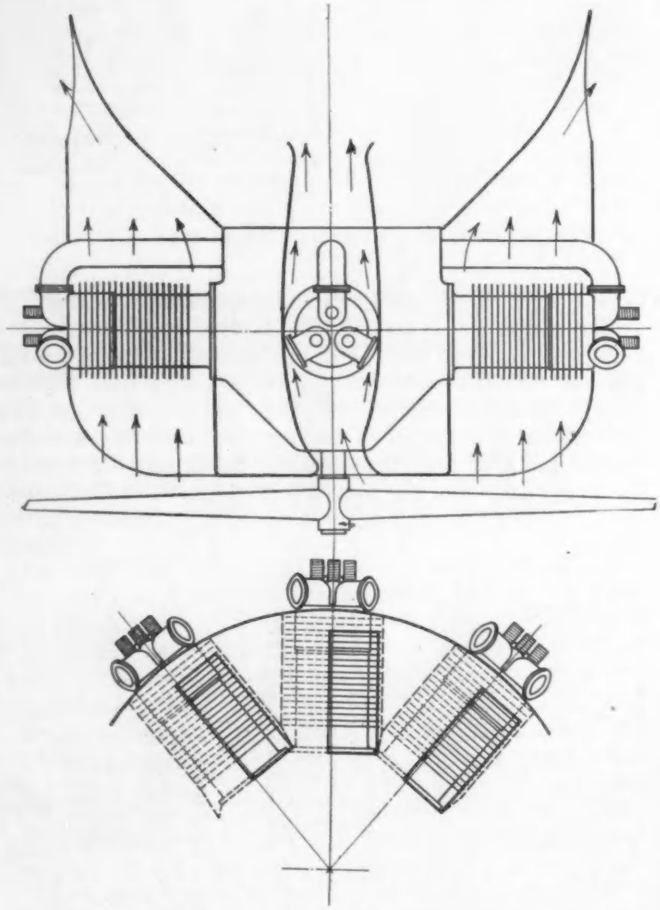


FIG. 5—COWLING ON A B.A.T. AIRPLANE OF 1919

grammatically illustrated in Fig. 5, cowls the cylinders to, or almost to, the top of the heads, and places each cylinder in a tunnel carrying its individual supply of cooling air.

Figs. 4 and 5 serve to show that the cooling, as regards providing direct airflow to all portions of the cylinder, can be as complete in a radial engine as in a line engine; however, such cooling is obtained at the expense of more complicated cowling and a greater amount of it, which makes the engine much less accessible than the similarly cowled in-line engine.

SPECIAL COWLING USED FOR BLOCK TESTING

Fig. 6 shows the cowling of the air-cooled Liberty engine as installed in an airplane. The scoop cowl shown in Fig. 7 is that used for torque-stand testing with a two-blade flying-propeller. It is somewhat unfortunate that a view similar to this has been published without explanation, as it has served to give a false idea of the amount of frontal area and head resistance of a modern air-cooled V-type engine. The scoop cowl used in flight has no forward rake and it is 29 in. above or below the center of the crankshaft at both front and rear for direct-drive engines. For geared engines, with the propeller on the crankshaft axis and a 5-to-3 gear ratio, excellent cooling was obtained with a 3-in. forward rake of the scoop.

Two views of the Wright V-1460 are shown in Fig. 8. This is, so far as the author knows, the only example extant in this Country of a really modern air-cooled V-type engine. It was designed initially as an air-cooled engine and embodies such modern features as a built-in supercharger and front-end drives for camshaft, supercharger and accessories. It may be well to point out that the cowling and exhaust arrangements shown in Fig. 8 were designed for torque-stand testing, and that in flight a scoop with no forward rake and with flush exhaust-stacks will be used; and that, in fact, all ground-testing to date has been carried out with such a scoop and a four-bladed club.

The installation shown in Fig. 6 does not represent the best that can be done in the way of a clean installation of a V engine. The sides of the engine may well be completely cowled, with improvement in resistance and appearance. Exhaust stacks are normally cut off flush with or ¼ in. beyond the outer surface of the scoop cowl. The untidy exhaust arrangement shown, with its inevitably high drag-figure, was necessitated by the position of the carbureter air-intake, which would have been liable to suck in exhaust gas if the stacks had been cut flush with the scoop. An Air Corps P1 pursuit airplane, with the installation shown in

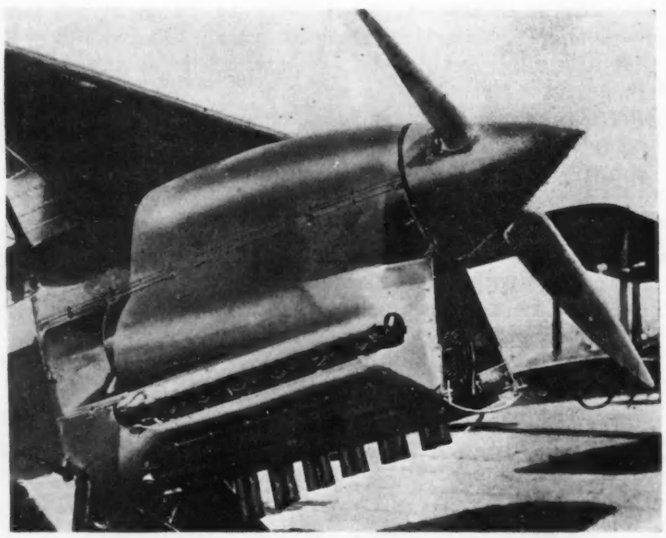


FIG. 6—AIR-COOLED LIBERTY ENGINE INSTALLED

Fig. 6, made 169 m.p.h. in level flight with an engine output of less than 450 hp. Admittedly, the plane was somewhat cleaned up from its normal condition for military use. This performance, obtained in 1926, is not to be despised even at this date.

As regards single-line-engine cowling, an example of a beautifully clean installation is shown by the DeHaviland Tiger Moth, which is worthy of study by those installing line engines. This airplane attained nearly 200 m.p.h. with an engine output of approxi-

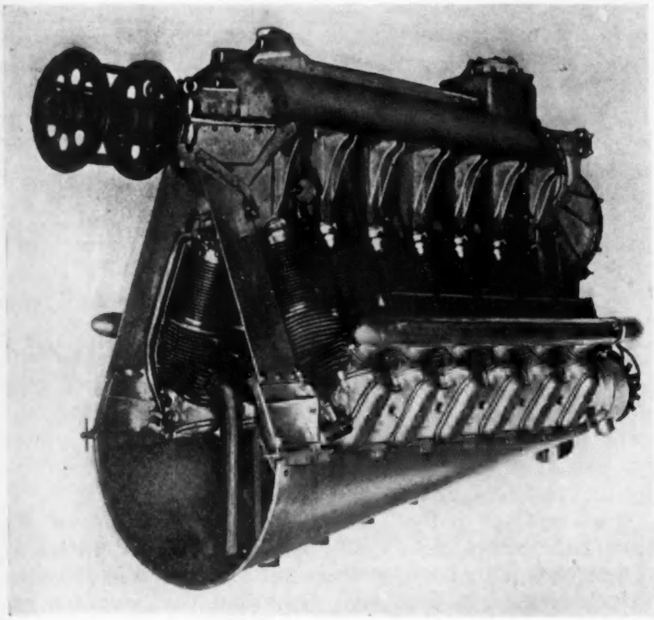


Fig. 7—Air-Cooled Liberty Engine Cowled for Block Test

mately 130 b.hp. and, while this is a racing airplane, it shows the possibilities of speed with the line engine.

Rotation of Slipstream Affects Cowling

In cowling line engines, attention should be paid to the spiral rotation of the slipstream. In the geared air-cooled-Liberty installation it was found in flight that the air entered the cowl at an angle of approximately 60 deg. to the line of flight. The right-hand front panel, extending from the camshaft housing to the crankcase, seriously interfered with the entry of air into the V, and cooling was much improved by its removal. In general, the entrance to the cowling should be arranged so that the air leaving the propeller enters with the minimum disturbance and interference.

In the installation shown in Fig. 6, the area of the entrance to the cowling was approximately 2½ sq. ft. and the engine was somewhat over-cooled, the temperature of the cylinder-barrels at the base being about 200 deg. fahr. This type of cowling allows ready adjustment of cylinder temperature by a simple installation of shutters in the entrance to the cowling.

The completely cowled air-cooled engine, as shown in Figs. 2, 4, 5 and 6, makes the velocity of the cooling air to a considerable extent independent of the slipstream velocity. By suitable design of the cowl entrance and by proportioning the exit louvers to produce suction, the velocity of the air in the fin cells can be made greater than the slipstream speed. However, it is in the high-speed airplane that the greatest advantage will result from complete cowling; the airspeed over the engine may then be only one-half or any desired proportion of that of the slipstream, and maximum slipstream velocities are not used in cooling such parts as valve gear, that need but little cooling. This should result in a very marked reduction in parasitic drag. If the entrance and exits of the cowl are suitably proportioned, the velocity energy can be converted into pressure energy and vice versa with but little loss. In general, it can be said that to date the effective cooling of V-type engines has proved at least to be as easy as that of the radial types.

The R.A.E. air-cooled V engines were, after a great deal of work, made to cool about as well as some modern radials, despite a 2-to-1 reduction gear which partly closed the entrance to the V, in addition to producing less favorable slipstream conditions. Further, the V was largely filled with inlet manifolds and similar obstructions. Light cast-iron I-head cylinders of the crudest variety were used, in spite of which the engines cooled with a fuel consumption not much in excess of 0.65 lb. per b.hp. at full throttle.

Relative Frontal Area of V and Radial Types

Fig. 9 shows the frontal-area profile of the Wright V-1460 superimposed on that of a 52-in.-diameter radial engine of about 1500-cu. in. displacement and

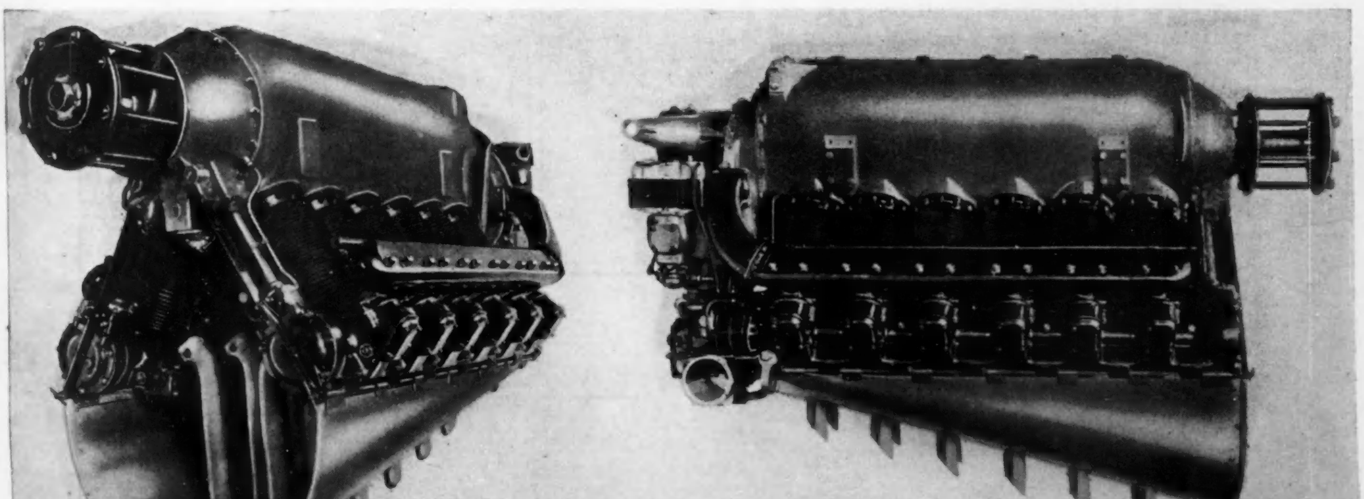


Fig. 8—Two Views of Wright Engine V-1460, Cowled for Block Testing

500 b.hp. The markedly lower frontal-area of the V-type engine can be seen readily. From this illustration the greatly improved forward vision available with the V type can be seen also. This is of great value for landing and for gun-sighting visibility.

Cylinder Position of Line Engines

The question whether the single line or V-type engine shall be upright or inverted is largely answered by the particular installation. In the case of the V engine in single-engine airplanes, the inverted position has overwhelming advantages as regards vision, exhaust disposal and exhaust noise. With the inverted V type, the use of stacks cut off flush with the surface of the scoop provides excellent exhaust disposal and a surprising suppression of exhaust noise in the cockpit. Its only disadvantages from the military viewpoint are that flame may be visible from the ground at night and that care should be taken to avoid exhaust entering the carbureter air-intakes. As the liability of drawing in exhaust through the air intakes is equally a liability of sucking in dust while running up or taxiing, the air intakes may well be placed considerably above the exhaust-outlet level.

The upright V engine with exhaust ports in the V, when installed in a single-engine machine or in the nose of a three-engine machine, results in poor vision and a choice between shooting exhaust into the pilot's face and manifolds that are sources of resistance and fire hazard.

In twin-engine machines with outboard installations, engines can readily be either upright or inverted without exhaust disposal or vision difficulties arising, except that in monoplanes the inverted engine probably is best for high-wing machines and the upright for low-wing types.

As regards the single line engine, this has at present but little field in military use except possibly for training, and just which position would be best for such use is open to question.

In commercial airplanes the inverted position seems best for vision, noise and exhaust disposal, but apparently there are certain disadvantages. It is understood that insurance rates in England are very mater-

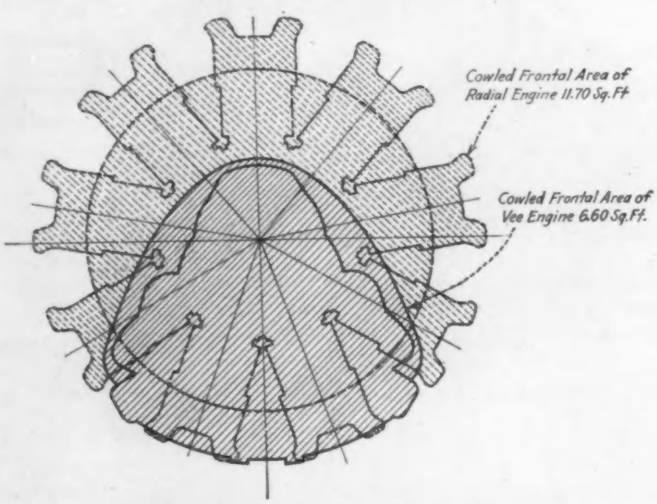


Fig. 9—Comparison of Engine Profiles

The Inverted V-Engine Is a Wright V-1460, Which Develops about 500 HP. The Radial Engine Is of about 1500-Cu. In. Displacement

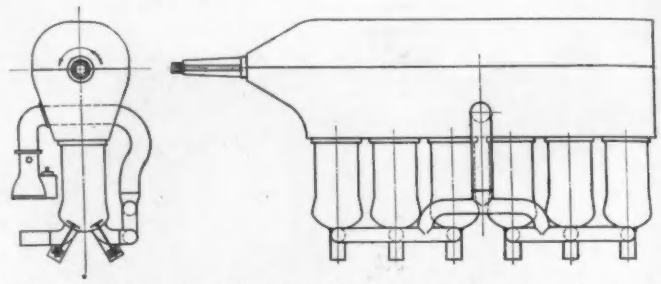


Fig. 10—Suggested Manifold Design for Inverted Engine

ially higher on commercial or flying-club airplanes with radial engines than on similar machines equipped with upright line-engines, owing to the fact that a landing-gear collapse or mild crash does not result in wiping off cylinders from an upright engine as it does the lower cylinders in the case of a radial.

This matter-of-fact, business-like conclusion of the insurance companies is well worthy of consideration in connection with both commercial and military-training installations. It has been remarked that engines are built to fly and not to crash, but cold commercial consideration will probably rule out such a view unless the advantages outweigh the risks.

Inherent Advantages of Inverted Engine

The inverted engine has certain definite advantages. Its piston lubrication is more certain during warming-

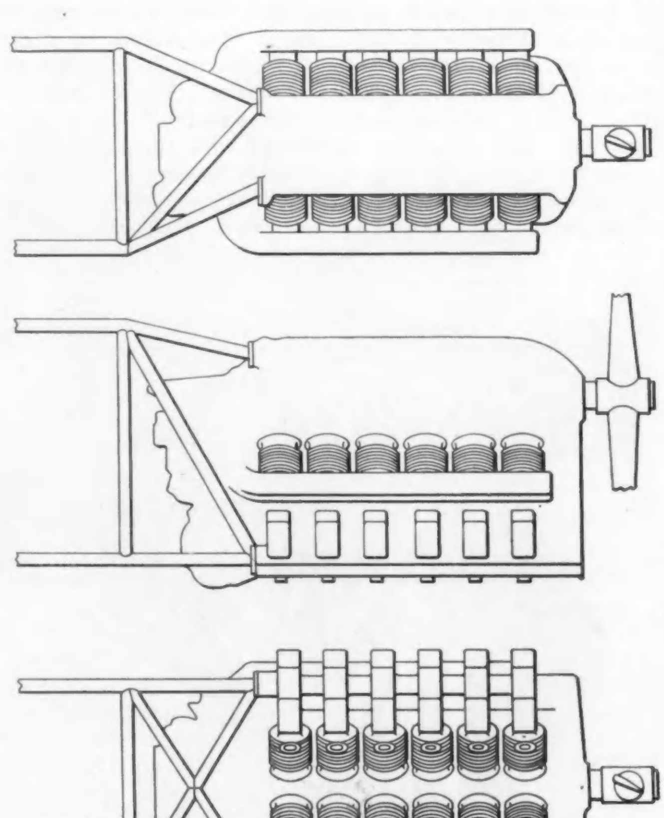
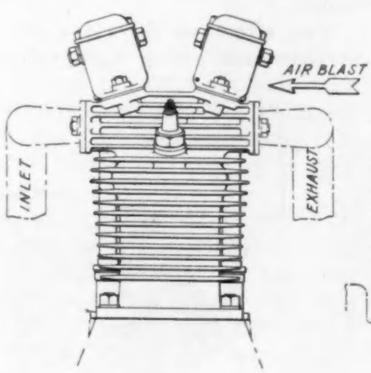


Fig. 11—Experimental Mounting of Inverted Engine

up periods, as any oil working past the main and connecting-rod bearings tends to fall toward the cylinder-walls rather than having to be thrown upward to them. Further, if enclosed and lubricated valve-gear is used, it can be given a very large oil supply, definitely assuring complete lubrication and a measure of cooling without danger of an excess of oil finding its way past the inlet-valve stems into the cylinders or past the exhaust-valve stems to the exhaust.

Problem of Inlet Distribution

Carbureter manifolding of the inverted line or V-engine is a rather difficult problem. On modern V-engines, rotary induction systems have been used almost entirely so far. With the gallery-type manifolds shown in Figs. 7 and 8, the distribution obtained in flight and in cold weather has not been very satisfactory. Carbureters projecting downward into the slipstream, with conventional manifolds on the outside of the V, involve so much resistance and so far destroy the appearance as to be almost unworthy of consideration. Manifolding similar to that used on the Rolls-Royce Condor, with the carbureters at the rear of the engine and above the lower cowl-line, can of course be used. In anything but the smallest single-line engine, a carbureter projecting beneath the cylinder-heads appears undesirable. The Condor system can be applied



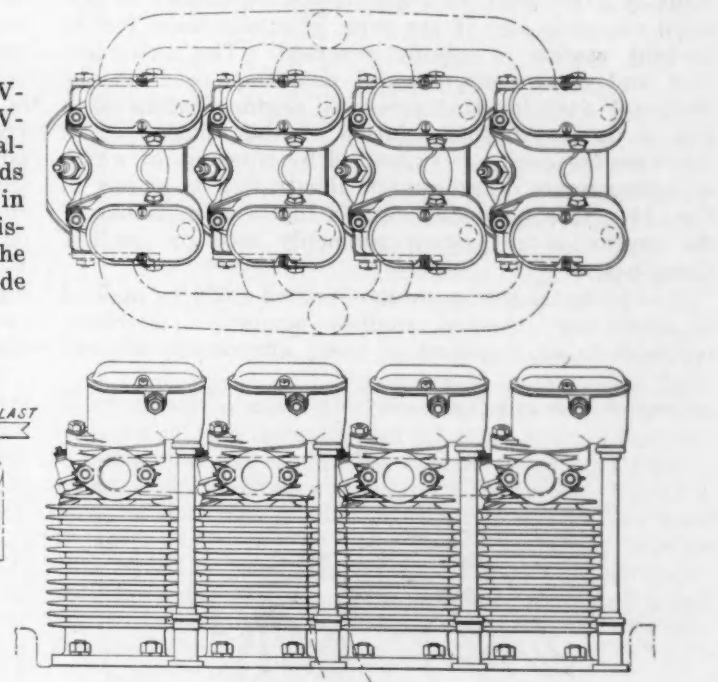


Fig. 12

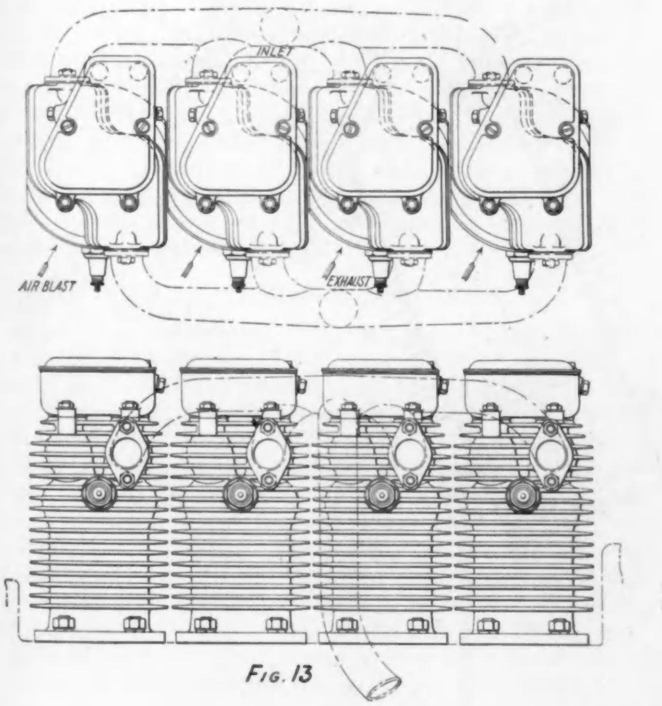


Fig. 13

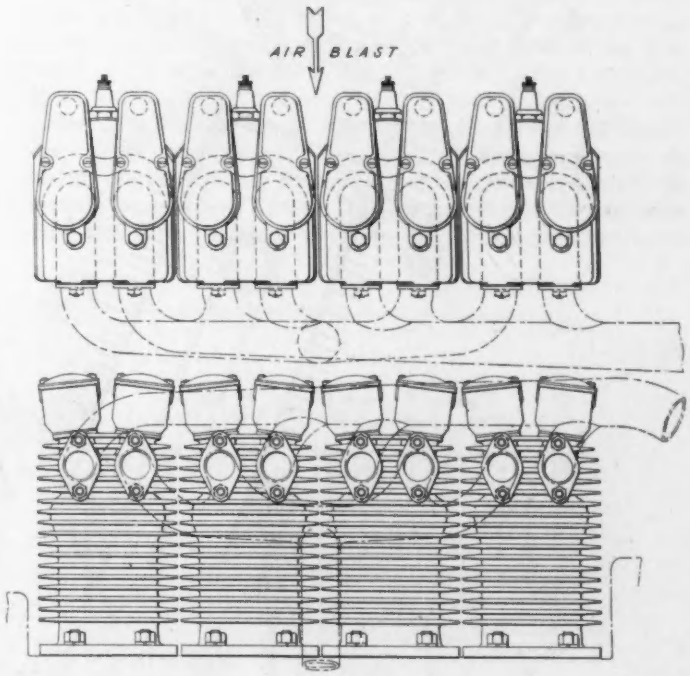


Fig. 14

Various Arrangements of the Ports and Valve-Operating Mechanism

Fig. 12—Ports and Push-Rods on Each Side

Fig. 13—Ports on Both Sides, Push-Rods on One Side

Fig. 14—Ports on One Side, Push-Rods Opposite

to inverted single-line engines as well as to the V-type. Fig. 10 shows a possible method of manifolding an inverted single-line engine that avoids a carbureter position below the cylinder-heads but has a fire hazard from carbureter drip to the exhaust stacks.

Mounting the Inverted Engine

The mounting of the inverted V-type engine is somewhat of a problem, as much of the advantage in forward vision is lost if the type of mount used for an upright engine is merely reversed. The extremely neat and clever experimental mounting used on the Wright V-1460 inverted air-cooled engine, illustrated in Fig. 8, is an original solution of this difficulty. In this case the engine is supported by trussing, of which an approximate diagrammatic illustration is shown in Fig. 11. This mounting results in the elimination of the engine-bearer system commonly used on upright V-engines.

It is probable that a similar method could be applied to single-line inverted engines where an overhead (cylinder-head) camshaft is used; alternately, a strut or struts, tying all cylinders together, could be used with a push-rod valve-gear. As far as can be seen, the sole disadvantage of this mounting is that removal of a camshaft housing or cylinder may involve removal of the engine from the airplane.

Cylinder-Head Design and Valve-Ports Location

Figs. 12, 13 and 14, which are automobile-engine layouts, show possible arrangements of valve ports with hemispherical cylinder-heads. In the author's opinion, that shown in Fig. 12 is the best; the closeness of cylinder spacing does not affect the permissible angle of valve inclination, and the design can be made entirely free from dead fin-spaces. In passing it may be well to point out that the spark-plug position shown is anything but advantageous as regards power output and fuel consumption.[2] This type of cylinder-head is used on the air-cooled Liberty, Fig. 15, and the Wright V-1460 and cools well. It can be made an excellent foundry-production job. It also allows the use of an overhead camshaft, to which further reference will be made.

The effect of directing the cooling blast so that it strikes first either the exhaust or the inlet side of a

[2] See The Journal, April, 1922, p. 254, and Proceedings of the Institute of Mechanical Engineers, 1923, vol. 2, p. 1075.

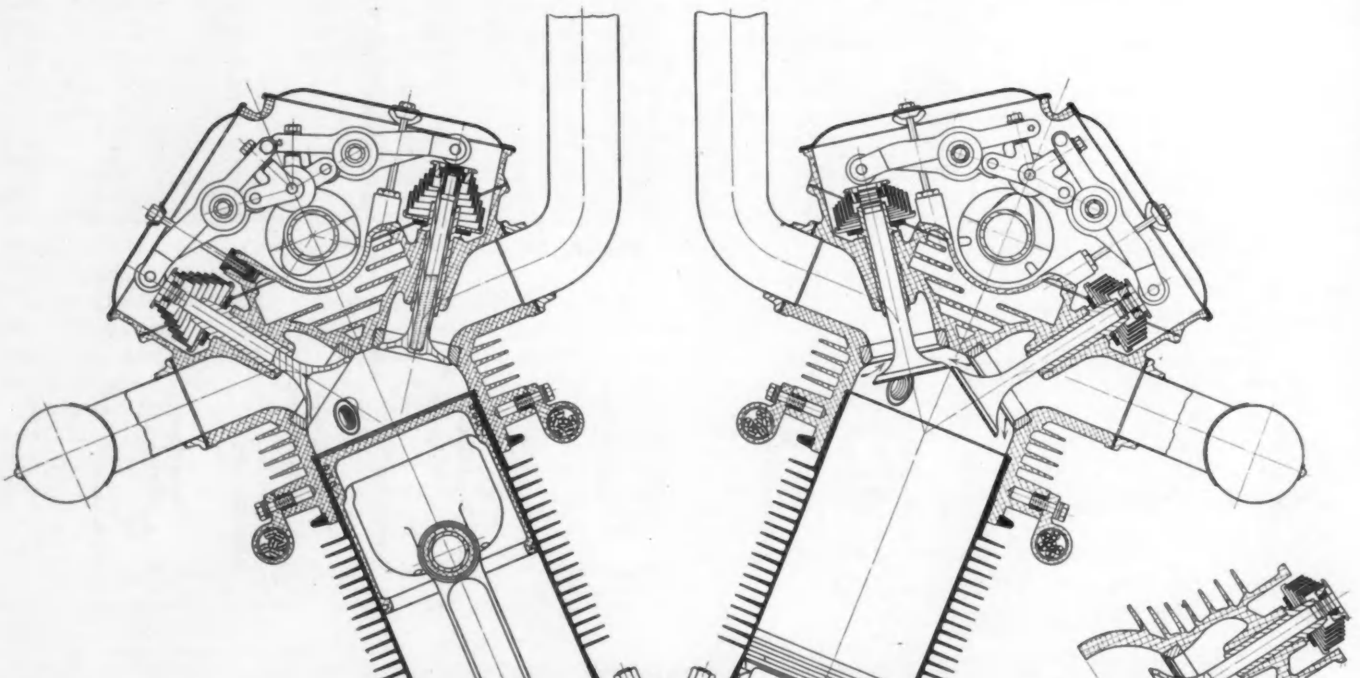


Fig. 15—Cross-Section of Air-Cooled Liberty-Engine Cylinder

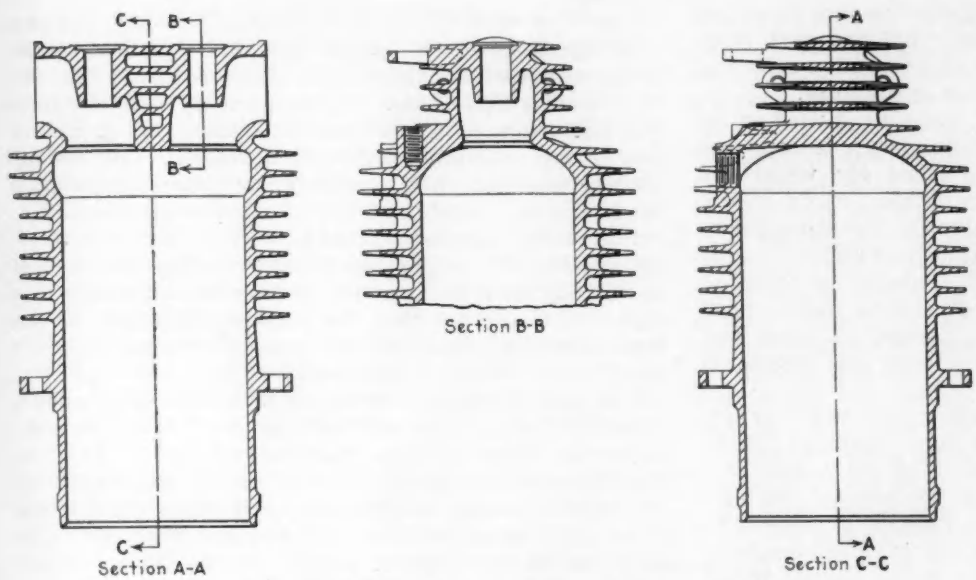


FIG. 16—AIR-COOLED CYLINDER WITH VERTICAL VALVES

cylinder of this type has been previously discussed[3], it being shown that application to the exhaust side has considerable advantage. For this reason, the exhaust ports are located in the V and the inlet manifolds on the outside of the cylinder banks in the air-cooled Liberty and the Wright V-1460.

The port arrangement shown in Fig. 13 is not considered to be as good as that in Fig. 12. The valve inclination is limited by the cylinder spacing, and the flow of air around the ports is not as free. The arrangement shown in Fig. 14 is considered inferior to that of Fig. 13, as the small valve-angle causes crowding of the ports, resulting in poor airflow around them and dead spaces. An arrangement of ports with vertical valves and what may be described as a truncated-roof head is shown in Fig. 16. This cylinder is used on the Wright-Morehouse engine and when installed with port directions as in Fig. 12, has, to a degree, the cooling advantages of the air-cooled Liberty type. In the author's opinion, it is the only type of air-cooled cylinder with vertical valves possessing anything like the cooling ability of the hemispherical or roof type with inclined valves.

VALVE-OPERATING MECHANISM

Air-cooled engines to date have been equipped almost exclusively with push-rod-operated valves. It seems to be a pronounced advantage of the in-line type that overhead-camshaft valve-operation can be used at little or no sacrifice of cost and weight. The advantages of the overhead camshaft may not be apparent on the surface. Study of mortality statistics of valves so operated, however, shows that breakage is so rare as to be almost non-existent. The valves in the water-cooled Liberty engine are of "notch-brittle" material, a poor grade of high-speed steel known to be arsenic bearing in many cases. The exhaust valves in the 180-hp. war-built Wright-Hispaño engine are of a relatively tough variety of stainless steel but so full of cracks and seams that, if they were etched before use, only a very small percentage would appear to be usable. Despite this, valve breakage is almost unknown in the Liberty; and no case of breakage in the Hispaño can be traced, although longitudinal cracks occur occasionally. The Curtiss D-12 uses notch-brittle valves, and no case of exhaust or inlet-valve breakage can be traced. The author knows of no push-rod valve-gear that can offer such a record of reliability.

The comparison is the more remarkable as push-rod-engine constructors are taking very thorough steps to secure soundness of valve material, and the fund of knowledge regarding valves and valve material has vastly increased since the war. Much of the valve trouble in push-rod engines has been charged to poor material. While this has been true to a large extent, the foregoing should serve to show that the modern push-rod engine has probably had consistently sounder valve-material than the Liberty and Hispaño. Some of the valve trouble in push-rod engines has been charged to the use of notch-brittle material; trouble with tough material also has been experienced, however, both here and abroad. It is probably true that tough materials have a greater inherent capacity of "swallowing" metallurgical unsoundness.

ENCLOSURE AND LUBRICATION OF VALVE-GEAR

The use of an overhead camshaft makes easy the complete enclosure and full lubrication of valve-stems, guides, rockers and other parts with a circulating oil-supply. This is valuable for its cooling effect and almost entirely eliminates valve-stem and guide wear, besides allowing the use of otherwise impossible materials for valves and guides. Present valve-gear practice on radial engines is not completely satisfactory. Complete enclosure without forced lubrication, while it excludes dust and dirt, provides a condenser for exhaust products

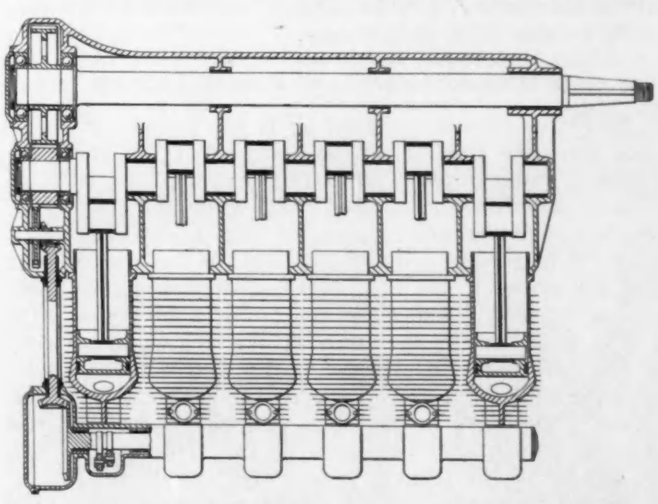


FIG. 17—INVERTED GEARED ENGINE WITH GEARS AT THE REAR
The Long Shaft Is Proposed as a Spring Drive

[3] See THE JOURNAL, April, 1922, p. 236.

and leads to corrosion and sometimes freezing up of the gear. Partial enclosure excludes wind and dirt from the push-rods but allows access of both, also rain and sea-water spray, to the valve-stems and guides.

If an enclosed gear with oil circulation is used on an air-cooled engine, it usually is cool enough to condense exhaust products. If properly drained, the water can be pumped to the oil-tank or crankcase, where it will finally be re-evaporated and breathed to the atmosphere. Line-type air-cooled engines with enclosed and lubricated valve-gear show a much greater tendency to condense moisture within the engine than do similar water-cooled engines. In cold weather, ice is formed at times and may result in internal breakage when the engine is started.

In any case, the ample oil-supply will very largely prevent corrosion except during long standing. Fully enclosed overhead-camshaft designs of valve gear for air-cooled engines have been, up to the present, the subject of but little attention and are inclined at present to be heavy and expensive, although it is questionable if a fully enclosed push-rod gear for a line engine would be much cheaper or much lighter.

The use of an overhead camshaft produces much more favorable conditions as regards transference of the valve-gear loading to the cylinder-head and thence to the cylinder-barrel and crankcase than occur in the push-rod type. In the latter type the mechanism for each valve usually is supported on the individual port, the loading is thus eccentric to both the port and the cylinder-head and is known to cause port leakage; it also results in the cylinder loosening up and cocking on the barrel threads. The use of compensated valve-gear, with push-rods, results in practically eliminating the bending moment on the ports and reduces both the amount and eccentricity of the valve-gear loading on the cylinder-head. In a good compensated gear, part of the load usually is transferred directly to the crankcase, and the loading is decreased owing to the reduced shock resulting from more nearly constant clearance.

In the overhead-camshaft type, the valve-gear can be designed so that the load causes no bending moment on the ports, and it is not transferred to the cylinder and thence to the crankcase. The general reaction is to avoid the overhead camshaft on air-cooled engines for fear that varying cylinder-expansion will cause bending of the camshaft and its housing. Tests have shown very little trouble from this source.

Cylinder Spacing and Engine Length

As far as experience goes, up to the present, it seems that adequate cooling can be obtained if the space between cylinder bores is 35 to 40 per cent of the bore.

It is sometimes suggested that, while the four-cylinder is a sound commercial engine, the six-cylinder is too long. It may be of interest to quote the figures for four and six-cylinder engines, each of approximately 400-cu. in. capacity, to develop 115 hp. at 2000 r.p.m. with 115 lb. brake m.e.p., with 6-in. stroke, spaces 40 per cent of the bore between cylinder bores, and without allowance for additional space between the center pair of cylinders. The bore of the four will be $4\frac{5}{8}$ in. and the extreme length over cylinders 26 in. The bore of the six will be $3\frac{3}{4}$ in. and the length over cylinders $31\frac{1}{2}$ in. Thus, the advantages of six cylinders are obtained with no great additional length.

Gearing the Propeller

The problem of the geared propeller will likely arise in the commercial-engine field in the future. The author is not aware of the successful use of toothed reduction-gearing with any production in-line engine having less than 12 cylinders and no flywheel. The use of toothed gearing on a four-cylinder engine without a flywheel is extremely difficult, if not undesirable.

Planetary gears have proved successful on nine-cylinder radials, but they are not cheap. For the commercial in-line engine with less than nine-cylinders, a gear design that is cheaper than the planetary type and at the same time has an inherent shock-absorbing capacity would have much to recommend it.

The modern six-cylinder automobile engine has shown its ability to operate with a very small flywheel, even under the rather arduous condition of pulling hard in high gear at low speeds. The spring drive provided by the relatively long propeller-shaft probably contributes in no small measure to the smoothness obtained under such conditions. With this in view, the design shown in Fig. 17 is suggested to provide a cheap and simple system of gearing for line engines.

The Materiel Division has investigated the variation from constant angular velocity at the propeller and the anti-propeller ends of in-line aircraft-engine crankshafts under widely varying conditions of running. The variation is not measurable at the propeller end, but it is of considerable magnitude at the anti-propeller end and is further magnified in drives taken from the anti-propeller end, the angular-velocity variation of camshafts driven from this point being sufficient to add considerably to the difficulties of high-speed valve-operation. Investigation has shown also that a length of shaft is apparently the soundest form of spring coupling, in that its angular deflection is proportional to the torque. In a spring coupling with initial loading of the springs the deflection is not proportional to the torque, and the load may rise to a considerable amount before any yield occurs; and backlash in the coupling is almost inevitable if initial loading is not used.

The design shown in Fig. 17 is practically only suitable for inverted engines, as the propeller thrust-line would be extremely unfavorable in an upright engine, at least as regards single-engine installations.

Suggested Design Gives Spring Drive

A long spring-driveshaft, analagous to the propeller shaft in an automobile, is provided. This should tend to absorb angular-velocity variations of the crankshaft and render slight variations of tooth spacing in the reduction gears of less importance than they would be with the gear directly behind the propeller. Constant-angular-velocity drives for the camshaft and accessories are also obtained. The highest point on the crankcase being at the rear of the engine, it is less objectionable from the standpoint of vision than it would if it were just to the rear of the propeller. In this arrangement any desired gear-ratio can be used, due regard being paid to its influence on engine cooling, although in this respect the increased distance of the propeller-shaft axis from the cylinder-heads results in higher slip-stream velocities at the cowling entrance than if the propeller axis were in the crankshaft center-line.

Gearing a line engine permits a higher rate of crankshaft revolution than would be possible with any rea-

sonable propeller efficiency in a direct-drive engine. Higher crankshaft speed means reduction of cylinder size and thus improves the engine in smoothness and compactness. With an overhead camshaft and a good valve-gear it would seem that adequate reliability can be obtained in commercial engines at 2500 r.p.m., especially as the use of air-cooling allows room for ample crankshaft and connecting-rod bearings. When the full-throttle endurance of cheap automobile-engines at speeds of more than 2000 r.p.m. is considered, it does not appear difficult to construct a line aircraft-engine as suggested in the foregoing.

The V engine, if inverted, probably is best geared generally with a planetary type of gear. If, for any reason, a higher propeller thrust-line is required, an adaptation of the type shown in Fig. 17 may be used, although it seems better to raise the whole engine by the amount it is desired to elevate the propeller and use a planetary gear. For the upright geared V-type, the planetary gear appears best; since the spur type, as shown in Fig. 1, cuts down the entrance area to the space between the cylinders and further results in the air being forced into this space by a less efficient portion of the propeller blade.

Production Manufacturing of Line Engines

Consideration may well be given to the suitability of the in-line engine to production from the angles of cost and assurance of maximum soundness and reliability in the finished parts. To the author, who makes no claim to be a production expert, it seems that the line engine is superior to the radial type in some respects and inferior in others.

As regards the crankcase, the radial appears to be better on the scores of soundness and reliability, as forged aluminum can be used without impossible production costs. The Pratt & Whitney radial engines illustrate the use of delightfully simple forgings for the highly stressed portions of the crankcase; in fact, for the entire crankcase proper. Forgings in general are much more trustworthy than castings. Pistons are, according to the author's view, an exception to this, as a piston design that has been modified sufficiently to allow forging and reasonably easy machining usually seems inferior to a first-class cast piston, although superior to a poor one.

Crankcases cast in permanent or semi-permanent molds may be possible for the line engine, and it is not unlikely that the resourcefulness of the American aluminum industry may one day produce inexpensive forged-aluminum cases for line engines. For the commercial line-engine at present, the use of even a semi-permanent-mold crankcase would seem to be satisfactory.

Crankshaft Types Compared for Production

The crankshaft of the in-line engine seems to be fundamentally the sounder forging design as long as integral balance-weights or balance-weight lugs are not used, and balance-weights are unlikely on account of the added weight. In a four or six-throw crankshaft it is relatively easy to arrange flow lines so that cross grain does not occur. In a radial single-throw two-piece crankshaft, avoidance of cross grain can be secured by the use of rather elaborate upsetting methods which are used in Europe but not, as far as the author knows, in this Country. In the case of the single-piece single or double-throw crankshaft with integral forged balance-weight lugs, the avoidance of cross grain in the balance-weight lugs seems to be commercially impossible. The machining of a four or six-cylinder crankshaft seems to be a simpler and cheaper operation than that of a radial-type engine with balance weights, particularly one of the built-up variety.

The single-line engine appears to have the advantage over the radial as regards connecting-rods. Forged aluminum or very light steel rods, either drop-forged to size or with rolled I-section and drop-forged and re-struck ends, can be used in the line engine. Machining of the big and little ends only will be required. The author has yet to see a radial-engine connecting-rod unit that allows of such ready forging and so little machining as does a complete set of connecting-rods for a six-cylinder engine.

In some cases, recent entrants to the aircraft-engine industry seem to feel that the elaborate and often involved methods of material control and general inspection used by the established constructors are unnecessary. Etching of aluminum castings and forgings in the rough and semi-finished states and of steel forgings and bars in the rough, the semi-finished and often the finished states, frequently is derided. Test-specimens and microphotographs taken from both ends of crankshafts are regarded with scorn also by some new constructors. Such a rigid system of control is not merely the result of design engineers' whims but rather the product of bitter experience in building engines of low specific weight. In the case of established and successful constructors, it is noticeable that the more successful they become, the more rigid become their inspection and control; first, as a safeguard of reputation; and, second, as being cheaper than wrecks and costly service far from the factory.

An increase of specific weight may allow a relaxation of many of the above precautions, but even the heavier commercial engines will be still a relatively highly stressed type.

THE DISCUSSION

Harold Caminez[4]:—Mr. Heron presented in his paper a strong case for the in-line type of air-cooled engine and clearly explained the more important problems which such a type entails. An advantage of some importance in favor of the in-line engine not mentioned by Mr. Heron is that these engines, by dispensing with the use of the master-and-link connecting-rod arrangement customary in radial engines, operate with less piston side-pressure.

Analysis of the kinematics shows that the piston side-pressures in the master-rod cylinder and the opposite link-rod cylinders are appreciably greater than they would be in similar cylinders of in-line engines. With lower piston side-pressure it should be possible to operate in-line engines at higher mean cylinder-barrel temperatures than would be permissible in the radial type of air-cooled engine. While cylinder-barrel cooling can be more readily and more directly obtained with radial-type engines, this higher permissible cylinder-barrel temperature should partly offset that.

Since the production costs of engines will have an in-

[4] M.S.A.E.—Brooklyn, N. Y.

creasing importance in the selection of engine types for commercial aviation, it is well to point out that there will always be a wide difference of opinion as to production economies between advocates of the two types of engine construction, and that some equally competent authorities will not agree with some of the views given in Mr. Heron's paper concerning production costs of the important components. The governing factors in cost of production will depend more on the detail design, the facilities and experience of the builders and the quantities manufactured than on the type of engine constructed. Commercial radial engines undoubtedly will be produced in the near future at lower cost, and it will be necessary for in-line engines to be designed with equal refinement of detail and built with equal knowledge of aircraft-engine practice to successfully compete in price per horsepower.

Use of Superchargers Advocated

Dr. Sanford A. Moss[8]:—Mr. Heron mentions in a rather casual way that, on modern V-engines, rotary induction systems have been used almost entirely so far. A little more may be said in this connection. There has been a tendency to think merely of a moderate-speed impeller inserted between the carbureter and the inlet manifold, which is expected to stir up the charge, and this has been called a rotary induction-system. Fortunately, however, the arrangement actually in use is a well-designed impeller, rotating at an appreciable speed and combined with a good diffuser, so as to give an appreciable pressure-rise and therefore properly to be called a supercharger.

The difference in cost between a crude impeller, which only attempts to stir up gasoline, and a well designed supercharger is very slight; hence, there is no good reason for using the so-called rotary induction-system. An actual supercharger, giving enough pressure-rise to yield some power-increase, may as well be provided. In fact, it may be questioned if the existence of a mere rotating wheel in the passage between the carbureter and the inlet manifold will really do much good, so far as mixing is concerned.

An impeller always tends to cause a concentration of liquid gasoline along the forward sides of the blades, and this gasoline will be thrown into the succeeding passage as actual drops, without much atomization. Furthermore, if an impeller is designed crudely, without sufficient attention to streamline flow, various eddies will be created. Gasoline will be thrown toward the outside of each of the whirls and irregularities, and so be separated from the air instead of mixing with it. A well-designed impeller, having streamline flow as nearly as may be, will avoid such tendency toward separation. A properly designed centrifugal supercharger has, beyond the impeller, a stationary passage called a diffuser, wherein the high velocity of the fluid leaving the impeller is gently slowed down and the corresponding kinetic energy converted into energy represented by pressure. An efficient diffuser adds greatly to the efficiency of a centrifugal supercharger.

If drops of liquid gasoline are thrown by the impeller into the passage of such a diffuser, they will pass in straight lines with constant velocity through air moving in curved lines with gradually decreasing velocity. This will result in continuous passing of each gasoline drop into new air, which is the exact condition required for vaporization. The net result is, as Mr. Heron states, that efficient distribution is secured with an inlet-manifold arrangement, such as shown in Fig. 9, with a single-barrel carbureter. The use of the supercharger permits the placing of the carbureter in a position that will not give the additional drag which, as Mr. Heron points out, is so objectionable.

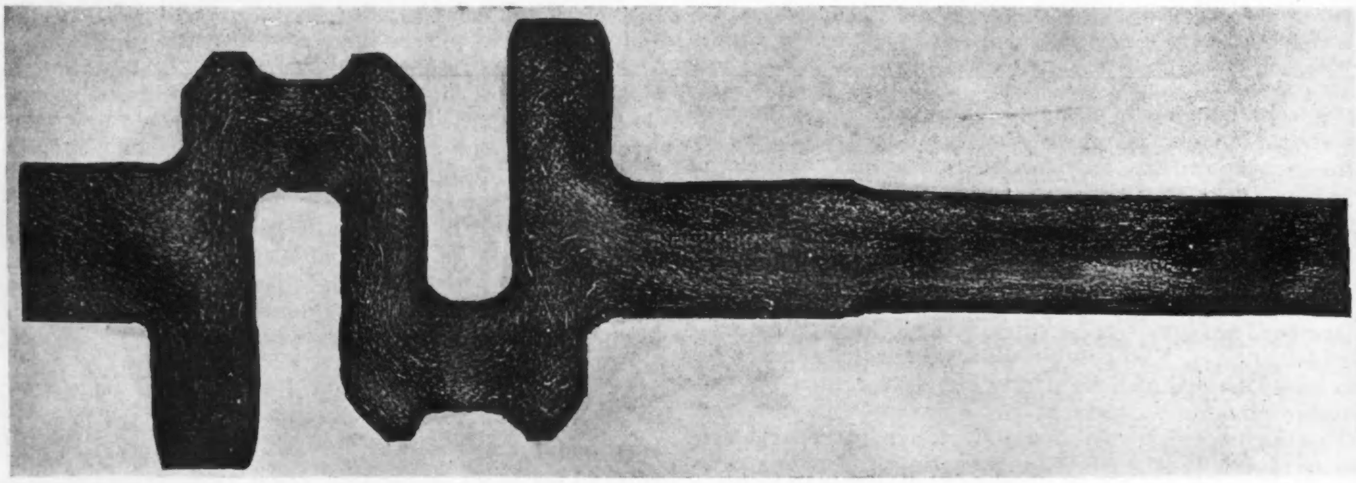


Fig. 18—Etched Section of Curtiss Challenger Crankshaft

Power Increase from Supercharger

In addition to all of this, a correctly designed centrifugal supercharger gives means for increasing engine power up to any amount which an engine will withstand. The Wright engine shown in Fig. 9 has had its power increased to a conservative extent by this means, and possibly further increase may occur.

The first applications of centrifugal geared superchargers to in-line engines were made by attaching the supercharger to the end of the crankshaft opposite the propeller. As Mr. Heron points out, there is an exceedingly variable angular velocity at this point. This resulted in failure of the supercharger drive in the early applications. However, in the case of the engine

[8] Thomson research laboratory, General Electric Co., West Lynn, Mass.

shown in Fig. 9, the Wright engineers have worked out a supercharger drive for the propeller end of the crankshaft which has given no difficulty. This involves the use of a long driveshaft from the propeller end of the engine to the opposite end, which gives a spring effect such as that to which Mr. Heron alludes.

Geared superchargers are an integral part of virtually all radial air-cooled engines now in production. The reasons which led to their adoption for radial engines apply with equal force to engines with cylinders in line.

Mr. Heron mentions that in-line engines will need to have high rates of revolution to compete with radial engines. This will mean increased velocities through the valves and other parts of the engine, which will cause an appreciable loss in power due to poor filling of the cylinders unless the pressure drop is compensated for by part of the pressure rise of the centrifugal supercharger. Additional pressure-rise will give increase of charge, and hence increase of power, to any desired amount.

ARTHUR NUTT[6]:—Mr. Heron says that cross grain cannot be avoided, commercially, in one-piece single or double-throw crankshafts with integral balance-weight lugs. Contrary to this, I wish to point out that we have perfect grain-structure in our two-throw crankshaft with counterweights forged integral. Fig. 18 is from an etched section of the crankshaft, which shows the perfect grain-flow that is being obtained commercially with no difficulty.

DISTRIBUTION DEFECTS NOT OVERCOME BY SUPERCHARGER

S. D. HERON:—The macrophoto shown by Mr. Nutt indicates that, even in a double-throw crankshaft with integral balance-weight lugs, almost complete avoidance of cross grain can be obtained; however, it appears that some inclined grain-structure exists at the junction of the balance-weight lugs with the main bearings. It is at this point that failures have been experienced from inclined or cross grain in single-throw one-piece radial-engine crankshafts.

In reply to Dr. Moss, it is stated in the published form of the paper that the distribution produced by rotary-induction systems has been rather unsatisfactory. This statement refers to systems in which the maximum obtainable pressure in the manifolds is not in excess of 3 in. of mercury above atmosphere. This is no reflection on the distribution obtainable with a suction-type supercharger. Such systems have effected a vast improvement in the distribution and smoothness of running of radial engines. It is worthy of note, however, that, even with efficient rotary-induction or suction-supercharger systems on radial engines, the use of carbureter air-heaters and hot-spots has been found desirable. In the case of the distribution systems shown in Figs. 7 and 8, the supercharger will not suffice to overcome the poor distributing characteristics of the manifold system used. On the ground in hot weather, smooth running and good distribution are obtainable; but in cold weather, on the ground and at altitude, a fairly large amount of heat applied either to the air or in a hot-spot is necessary.

In general, it has not proved desirable to use a supercharger to overcome distribution defects of a manifolding system on air-cooled engines. Rather would it appear sound to use a manifold having inherently good distributing characteristics without a supercharger and obtain still better distribution with the addition of the supercharger.

Dr. Moss refers to the use of superchargers to maintain cylinder filling at high engine-speeds. The supercharger undoubtedly has numerous possibilities in this connection. However, this procedure often results in neglecting to secure the maximum efficiency of power output from the cylinder and manifold design. Reliance for power output is placed upon the pressure rise of the supercharger, and the viciousness of the proceeding becomes apparent only when additional supercharging for altitude is required. Under such conditions, it is evident that a considerable portion of the pressure rise allowable without the use of an intercooler has been expended in obtaining the required full power at ground level. The supercharger should not be regarded as a substitute for sound cylinder and manifold design.

Dr. Moss points out the greatly increased power-output possible with supercharging. However, to make an air-cooled engine withstand the added output is usually much less simple than the addition of the supercharger.

It probably is true, as Mr. Caminez suggests, that the reduction of piston side-thrust, secured by eliminating the master-and-link connecting-rod arrangement, should allow the cylinder-barrels of the line type to be run hotter; but the piston-rings of modern air-cooled V engines to date have shown a tendency to stick at considerably lower barrel-temperatures than are necessary to produce this trouble in the best types of modern radial-engine. Therefore, it seems that, until more is known about V types, it is undesirable to consider running engines hotter. As the frontal area of the cowling necessary to cool adequately a line engine is small, other features may well be concentrated on.

The modern tendency to raise the cylinder temperatures of air-cooled engines is not without undesirable effects on durability and on the class of fuel and oil required.

In the paper as delivered at the meeting, it was stated that, in an overhead-camshaft type, the valve-gear load is transferred to the cylinder-head and thence to the barrel and crankcase. E. T. Jones, in private discussion, pointed out that this is incorrect, and that the valve loads are self-contained within the cylinder-heads and camshaft housing.

---

[6] M.S.A.E.—Chief engineer, motor division, Curtiss Aeroplane & Motor Co., Inc., Buffalo.

A Cure for Shimmy and Wheel Kick

By J. G. Vincent[1] and W. R. Griswold[2]

Annual Meeting Paper

Illustrated with Photographs and Drawings

Beginning with a review of the effects of the almost simultaneous adoption of balloon tires and front-wheel brakes, the authors outline the dynamic conditions of the front-axle system of the conventional car. They show that two types of vibration, otherwise independent of each other, are coupled together by gyroscopic forces when the wheels are rotating. The effect is greatly to lower the frequency, so it can come into synchronism within the speeds at which the car is driven.

Shackling the front springs at the front end reduces the error in steering geometry, but cannot always entirely eliminate shimmy and wheel kick. A solution was found by adding a cushioned bracket at the rear end of the left front spring. This introduces damping, because of a phase difference between the gyroscopic forces and the elastic and friction forces, thus eliminating shimmy and at the same time reducing the reaction at the steering-gear to an amount so small that no kick is felt at the steering-wheel rim.

Further analysis of shimmy is given in the discussion, and two speakers state that independent springing of the front wheels seems to be the only sure cure. Another speaker reports that independent springing has proved unpopular in Europe, where it has been most extensively tried.

Probably no other change in the evolution of the automobile has brought to focus such a large variety of problems as has the balloon tire, and these problems have been difficult to understand. The effects have been noteworthy as to the range of their influence, even extending to considerations of engine type and to radical changes in front-wheel suspensions to overcome defects exposed by low-pressure tires.

Shimmy and wheel wabble and allied vibration phenomena of the front suspension manifested themselves sharply when balloon tires were first introduced, but clutch and transmission jazz, and vibration periods when coasting down from higher car-speeds are also phenomena directly associated with balloon tires. They are new aspects of engineering which must be taken into account in designing cars on which balloon tires are to be used. It is impossible to cover in a paper of convenient length a serious discussion of all of these aspects; and the scope of this paper has been limited to those problems seated in the front suspension, as they are the ones giving probably the greatest concern. These are the inseparable problems of riding comfort and steering.

Before the advent of balloon tires, steering was worked out for high-pressure tires having small ground-contact. It was not then a problem presenting fundamental difficulties. Easy steering could be had with layouts providing for the reduction of friction to the minimum, and steering ratios could be chosen within ranges acceptable for fast driving. The larger cars presented no particular problem, because their tire pressures were higher; consequently, the area of ground contact did not increase in proportion to the weight.

Shimmy and wheel tramp were practically unknown, and wheel wabble was a product generally attributed to excessive wear or faults in design that permitted too much backlash in the steering hookup. Looking back, we realize that the high-pressure tires were hard riding; but, even so, the tire situation was considered as a fixed condition, and engineers had to look elsewhere to win improvements in riding comfort. Such factors as wheelbase, weight distribution, spring flexibility, shock-absorbers and cushion design were the only ones taken into account. Even the best results, as we look back, were indifferently successful and never quite fulfilled our desires.

Balloon Tires Brought Good and Harm

There is little wonder, then, that the balloon tire found a ready acceptance; and, because its adoption came almost simultaneously with the adoption of four-wheel brakes, we acquired some rather baffling problems. In some cases, notably our own, the adoption of four-wheel brakes preceded the adoption of balloon tires; in others the balloon tires came first. Those who had the four-wheel brakes first were confronted later, when balloon tires were adopted, with the various phenomena known as shimmy, wheel tramp, wheel wabble, steering-wheel kick, radiator shimmy and hard or slow steering, all of which were greatly undesirable. Nevertheless, these were accepted as the necessary evils complementary to the much improved riding-comfort which no one was willing to forsake.

In addition to these faults were introduced others, such as clutch jazz, transmission jazz, and vibration emanating from engines of some types when coasting at the higher speeds. These were at first little understood to be the progeny of balloon tires; not as the sole parent, of course, but in combination only with engines of certain types, particularly six-cylinder engines.

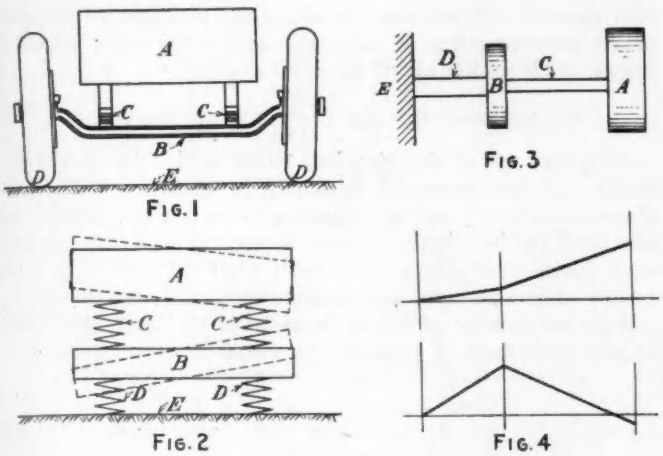
It was natural that balloon tires and their makers should be roundly denounced for these faults. However, some good came out of the resulting conflict; at least, the tendency to abnormally large tires was checked, and tire manufacturers gave their attention to features such as unbalance, where alleviation of troubles seemed to be possible.

Progress Demanded Analysis

To students of the changes brought about it appeared that definite progress could be made only by recognizing

[1] M.S.A.E.—Vice-president in charge of engineering, Packard Motor Car Co., Detroit.

[2] M.S.A.E.—Engineer in charge of analysis of design, Packard Motor Car Co., Detroit.



FRONT AXLE VIBRATORY SYSTEM

Fig. 1—Elements of Front Axle and Chassis
Fig. 2—Representation of Mass and Elasticity of the Axle and Chassis
Fig. 3—Torsional Equivalent of the Axle System
Fig. 4—Modes of Vibration of the Axle System

the engineering aspects of cars with balloon tires as a unified problem, and by determining the fundamental nature and correlation of the objectionable phenomena. To begin with, the troubles associated with the adoption of balloon tires could not be anticipated, which is no doubt a very fortunate circumstance for progress. The undesirable manifestations therefore provided a basis upon which to begin a study of fundamentals.

Those who have observed the phenomenon of front-wheel tramp, which perhaps is the best manifestation to use for analysis, describe it as follows:

The axle oscillates transversely about a horizontal axis longitudinal of the car, with the wheels bouncing alternately on one side and then the other; the front end of the chassis oscillates in a similar manner, but on the side where the chassis is moving downward the axle is moving upward. All the while the wheels and spindles are oscillating about the steering-knuckle pivots—with corresponding movements of the steering-wheel, even though strongly gripped in the driver's hands.

The oscillations of the wheels are accompanied by a movement of the car along a sinuous path. The observer also is aware that this manifestation occurs at a more or less definite critical speed of the car and that the critical speed can be altered in a number of ways. By changing the tire pressure, the critical speed can be either raised or lowered; changing the springiness of the steering hookup, altering the reversibility of the steering-gear, blocking the front springs out, taking off the front-wheel brakes, bracing the frame, changing the fore-and-aft rake of the axle, and changing the shock-absorber settings are the more common ways of altering the phenomenon. All of these peculiarities prove the existence of a mass-elastic system that can be analyzed.

A very significant characteristic of this phenomenon is that, whenever the critical speed is reached, even on a smooth concrete road or a macadam boulevard, the vibration will begin without delay and grow to violent proportions very quickly. This alone is not only proof of the existence of a mass-elastic system possessing definite frequencies of instability—or, rather, definite frequencies of vibration where resonance with some exciting force will indefinitely prolong violent vibrations—but it further shows that a condition of excitation exists within the system itself.

Simplified Equivalents

Analysis shows the front-axle system to be a complex elastic-mass system comprising two systems, which can be more easily understood if reduced to simplified equivalents of the two separate systems. The axle system shown in Fig. 1 comprises the mass *A*, of that part of the chassis which is effective as sprung mass; the mass *B*, which includes the inertia mass of the axle, wheels and tires and those parts attached or carried by them, such as the front-wheel brakes; leaf springs *C*; and the elastic supporting portion of the tires *D*. The road is *E*. This system might be represented by the diagram in Fig. 2, in which the corresponding parts are indicated by the same letters as in Fig. 1.

From our previous observations we know that the movements during vibration are rotary oscillations in which the polar mass inertias of the parts are effective, and the springs exert elastic couples by virtue of the rotary motions of the masses, as shown in Fig. 2. Further simplification may be resorted to as shown in Fig. 3, in which *E* represents the road, or an inflexible mass of infinite amount; *D* is a torsion spring having the same torsional elasticity as is produced by equal but opposite deflections of the tires; *B* is a mass having a polar moment of inertia equal to that of the axle assembly about a horizontal axis through its center of gravity; *C* is a torsion spring of the same torsional elasticity as is produced by equal deflections of both springs in opposite directions from the normal rest position; and *A* is a mass of the same polar inertia as the effective chassis weight.

The simple equivalent torsional system now presents

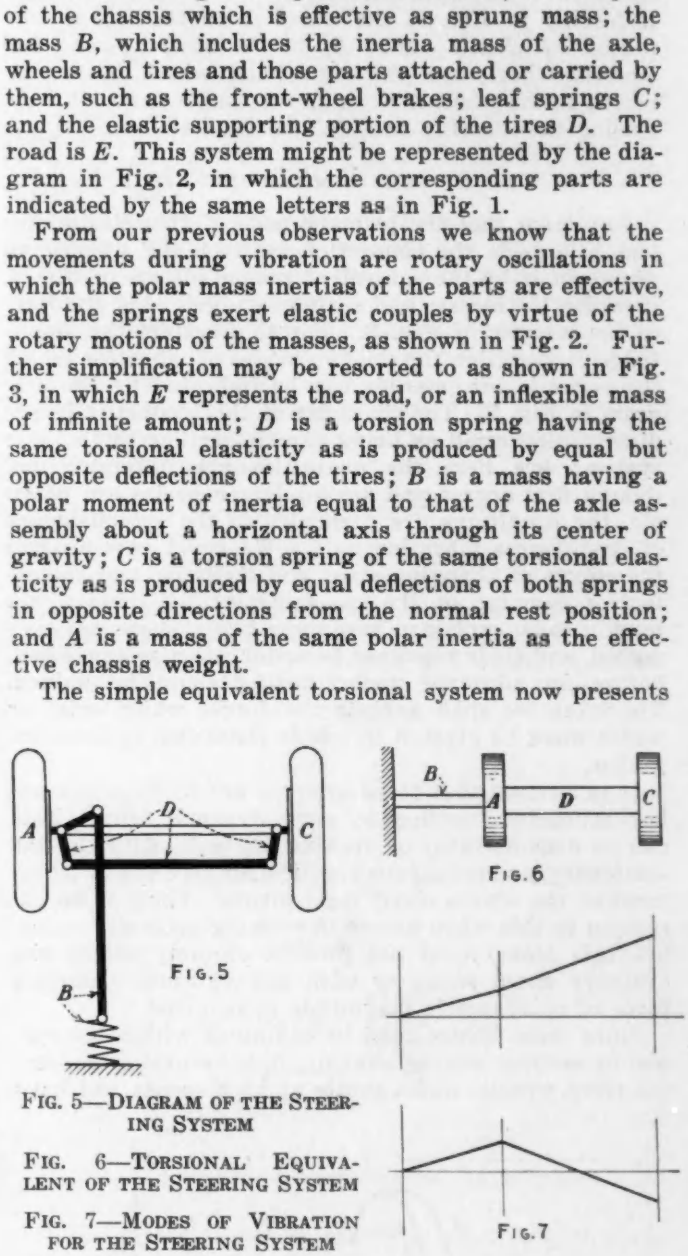


FIG. 5—DIAGRAM OF THE STEERING SYSTEM

FIG. 6—TORSIONAL EQUIVALENT OF THE STEERING SYSTEM

FIG. 7—MODES OF VIBRATION FOR THE STEERING SYSTEM

no difficulty to the calculation of its natural frequencies, or to the immediate recognition of a system with two degrees of vibration. Since it is composed of two masses, we readily discern the ability of the axle and chassis to vibrate in phase, which results in the lowest frequency, or to vibrate in opposite phase, with a much higher frequency.

We may represent the amplitude for these two modes of vibration by the curves in Fig. 4. It is also evident

that, if a periodic force is applied to either of the masses or the springs, a state of resonance will be established as soon as the frequencies of the force become the same as either of the natural frequencies of the masses. In this respect the nature of the phenomenon is not unlike that of torsional vibration in the crankshaft of an engine.

Similarly, the wheel system may be reduced to a simplified equivalent. In this case the wheels oscillate about the steering-knuckle pivots in a rotary motion. Referring to Fig. 5, the wheel *A* on the left is connected by elastic parts, *B*, to the steering-gear and steering-wheel; and the right-hand wheel, *C*, is connected to the wheel *A* through the elastic parts, *D*, comprising the steering-knuckle arms and tie-rod.

Two Systems Similar in Effect

Assuming that the primary node of this elastic system is outside the connection between the wheels, we represent it by the equivalent system shown in Fig. 6, in which the masses and springs are indicated similarly to the manner of Fig. 3. For this system the amplitudes of vibration for the two modes of vibration which theoretically are possible can be indicated by the diagram in Fig. 7. The character of this system is immediately recognized as being exactly similar to the axle system; but here the quantities are different and, though first-degree and second-degree modes are possible, the conditions are conducive to the establishment of first-degree vibration only. We could now analyze the effects of changing mass and elasticity and the effect of damping on the two systems; but there would remain to be explained how these two systems are connected, and their resultant behavior when so connected, before an adequate understanding could be gained. Therefore we shall analyze the forces which exist or which must be created to couple these two systems together.

It is obvious that these systems are independent unless connected together by some dynamic force. This can be demonstrated by rocking the axle, with the car stationary, and noting the practical absence of any movement of the wheels about their pivots. There is an exception to this when errors in steering geometry occur, but this alone could not produce shimmy within the ordinary speed range or with any violence. Another force of considerable magnitude is required.

Since these forces must be contained within the system of motions during shimmy, it is natural to suspect the front wheels, which rotate at high speeds and have two degrees of freedom in addition; making an almost exact reproduction of the toy gyroscope with gimbel rings, with which all of us are familiar.

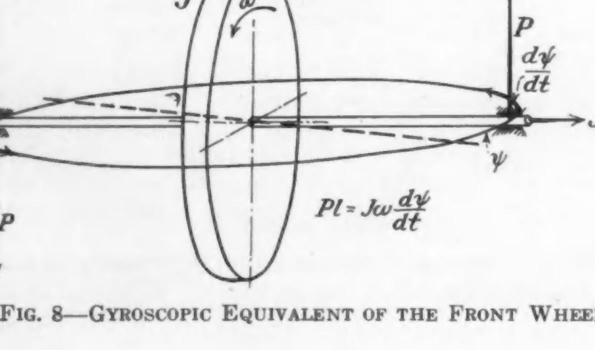


Fig. 8—Gyroscopic Equivalent of the Front Wheel

Gyroscopic Forces Couple the Systems

A gyroscope of the simplest form, which is more correctly called a gyrostat, is shown in Fig. 8. This consists of a heavy wheel rotating on an axle, which is mounted on bearings in such a way that it can rotate in a plane containing the axle; that is, the axle can rotate about an axis perpendicular to its own axis.

Any movement of the axle parallel to itself, whether or not the wheel is rotating, is resisted only by the inertia of the mass. If the wheel is not rotating, any rotation of the axle about any intersecting axis will be resisted by a couple equal to the polar inertia of the mass with respect to that axis. If the wheel is rotating, however, any angular change in the axle position such as that sets up gyroscopic forces. Such motion of the axle is called precession, and it can be resolved into the two principal planes of projection, like other forces. In Fig. 8, the rotation of the gyroscope and the precession of the axle are indicated.

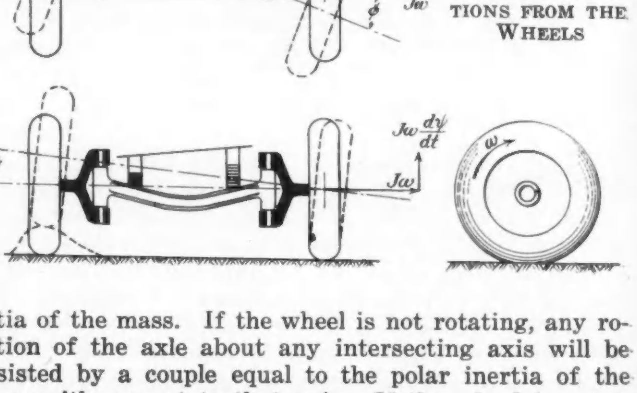


Fig. 9—Gyroscopic Reactions from the Wheels

The term "precession" distinguishes the motion from simple rotation of the flywheel about its axle. Because of the rotation of the wheel and the precession in the directions shown in Fig. 8, a gyroscopic couple is created, acting on the bearings of the axle as indicated.

The value of this couple is a function of the polar mass of the flywheel, its rotation in revolutions per second, and the velocity of the precession. If the precession is reversed while the wheel is rotating in the same direction, the gyroscopic couple will be reversed. This is the simplest illustration of the force relationship.

If, however, additional precession takes place in the plane of the couple illustrated here as the plane of the paper; that is to say, if movement of the axle also takes place in that direction while it is precessing in the plane indicated by the circle, then another couple will be created. Thus the motions and forces of the gyroscope or gyrostat become very complex when the degrees of freedom of movement of the axle are increased. This condition is shown in Fig. 9, in which corresponding factors are marked with the same letters as in Fig. 8.

With this reciprocal relationship of forces, it seems easy to see how the two vibrating systems of the front-axle system are connected together by means of the gyroscopic action of the wheels where the front wheels are capable of rotation on the steering-knuckle pivots. At the same time, the axle itself can rotate in a vertical

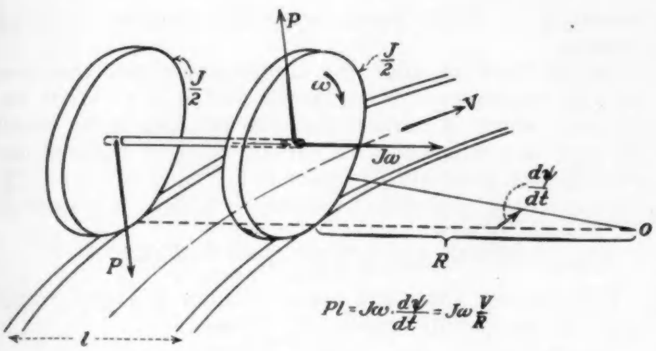


FIG. 10—GYROSCOPIC EFFECTS DURING A TURN

plane transverse to the car, that is, rotate about an axis approximately at right angles to the plane of the pivots. Thus it is clearly evident that, if the wheels are wabbling back and forth about the pivots, couples will be created tending to oppose or increase the movement of the axle rotation in its principal plane. Conversely, if the axle is rotated by the tire in going over an elevation, a right-angle couple is created tending to wabble the wheel about its pivot.

EFFECT OF GYROSCOPIC COUPLING

This action, however, has a very interesting and decided effect upon the compound elastic system composed of these two separate systems connected together by means of the gyroscopic action. Mathematical equations help greatly to a full understanding of the motions and forces set up between these two elastic systems, but perhaps a few generalizations will help without going into intricate mathematics.

For simplicity leaving out damping or friction forces for the moment, we have, in the case of the axle system alone: (*a*) the inertia force of the axle and wheel assemblies with respect to their rotary acceleration around the longitudinal axis, (*b*) the restoring elastic forces due to the suspension springs and the tires, and (*c*) the gyroscopic couple acting in the plane of the axle rotation. Similarly, in the case of the elastic system containing the wheels and having to do with their motion around the pivots, we have: (*a*) the inertia forces of the wheels with respect to their acceleration about the pivot axis; (*b*) the elastic restoring forces which are due, as before stated, to the elasticity of the steering connection and the force exerted by the driver gripping the steering-wheel; and (*c*) the gyroscopic couple due to the precession in the plane of the axle.

If these three forces for each system are written in the form of two differential equations and the equations solved simultaneously, we shall find in solving for the time of oscillation of the combined system that the periods will be very much longer than if the wheels were not rotating. In other words, if the axle has a period of 1 sec. when the wheel is stationary or nonrotating, which is not the magnitude of an actual period but is suitable for explanatory purposes only, the effect of the gyroscopic couple would increase the period to perhaps 2 or 3 sec., depending on the magnitude of the gyroscopic couple.

The same holds true for the elastic wheel-system. The direct result of this is that the natural frequency for both systems has been greatly lowered from what it would be without the action of the gyroscopic couple; that is, the periods are greatly lengthened. We have already seen, or we can judge, that with the adoption of balloon tires we have reduced the frequency and increased the period correspondingly for a complete vibration, because of the lowering modulus of the restoring force. Also, by adding the mass of the brakes we have added inertia to the elastic system, which has a further tendency of reducing the frequency or increasing the period.

Likewise, the adoption of four-wheel brakes has added considerable mass to the wheels and, therefore, has increased their inertia with respect to the steering-knuckle-pivot axis. The result of this is that the front-wheel system is now not so stable as it was with the frequencies higher and the periods shorter. This provides opportunity for resonance with the unbalance of the wheels or with any other periodic forces that may be applied to them.

The effect of the gyroscope is, therefore, not so much in exciting vibration as in lowering the frequency and bringing the instability of the system within a range such that resonance can easily occur. When the system is disturbed by road shocks or any other condition causing precession, the wheels would give a few spasmodic kicks and the vibrations would die out under the influence of the damping forces if there were no other exciting forces. However, other forces are created which maintain the vibration.

EXCITING FORCES

One of the exciting forces is a gyroscopic force of another nature, which arises because of the kind of path over which the car passes when the wheels are deflected from their straight-ahead position. The nature of this force is illustrated in Fig. 10, in which

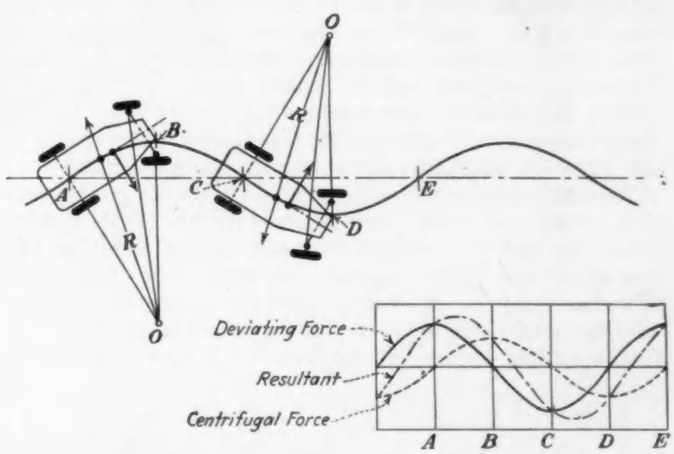


FIG. 11—FORCES ACTING DURING AXLE TRAMP

O is the center of curvature of the track or path made by a pair of wheels. The wheels are rolling forward along the curve in the direction shown by the arrow. It will be seen that precession is taking place with respect to the center of curvature of the path and that, therefore, a couple is created which tends to lift the inside wheel and depress the outside wheel.

In addition, there are the dynamic forces acting on the chassis. These comprise two principal forces acting on the system to maintain the vibration or shimmy of the front wheels. The condition can be made more clear with the aid of Fig. 11, in which the car is shown

following a sinuous path during a state of wheel wabble or shimmy. This path is a sine curve, the zero axis of which is the mean path of the car.

When a car is traveling at a constant speed along a path of changing curvature, two forces must act to compel the car to follow that path: the well-known centrifugal force due to the acceleration of curvilinear translation, and a force acting through the center of percussion to rotate the car about a vertical axis through its center of gravity. Without this couple the car would be exactly parallel to itself at all points along the sinuous path. These two forces have the same period but differ as to their phase relation. The centrifugal force is greater as the radius of curvature is smaller, while the deviating force depends only on the rate of change of curvature of the path. In this case, for instance, the centrifugal force is zero when the locking angle of the wheels is zero, and increases directly in proportion as the locking angle increases; the deviating force, however, is maximum when the locking angle is zero and is zero when the locking angle is maximum.

The relation of these two forces is shown by the two curves in Fig. 11. The resultant therefore acts as a single force out of phase with the locking angle of the wheel. It lists the chassis first to one side and then to the other, continuously adding energy to the system and causing the vibration to grow until an equilibrium is established with the damping forces.

With this kind of resonance it is not necessary that the period of the vibration be equal to the period of wheel rotation, since the period of the exciting forces is independent of the wheel period. The shimmy may be produced by a resonance with the forces due to unbalanced wheels, in which case the time of oscillation of the axle must be equal to the time of revolution of the wheel. Under this condition, any unbalance of one or both wheels, regardless of their relative positions, forms an exciting couple which tends to rotate the wheels about the steering-knuckle pivots and at the same time cause a change in the spring deflection and the pressure exerted by the tire on the ground.

Any movements caused by these unbalanced couples will of course become resonant with the axle system when the period of wheel rotation is the same as the period of the axle system. Although the front-axle vibration may be excited by this resonance, it is likely to degenerate under the influence of the deviating forces acting on the car to become simply a resonant condition by which these forces take control of the vibration.

In the face of such a complex situation, the most natural questions for engineers to ask are: What can be done about it? and What are the means by which shimmy and wheel wabble can be avoided without sacrificing the good riding-qualities of balloon tires? To answer these questions, rational analysis is essential.

Means for Suppressing Shimmy

Fortunately, there are certain damping forces which may be beneficially employed. These are:

(1) Interleaf friction of the springs
(2) Friction in the shock-absorbers
(3) Friction in the steering connections
(4) Friction in the steering-gear
(5) Damping forces due to the pivot angle
(6) Damping forces due to the rake angle.

Of these, we have some control over the friction in the shock-absorbers; also, if steering ratios are optional through a suitable range, the friction in the steering-gear can be controlled to some extent. The pivot angle and rake angle could of course be selected by trial to get the desired damping action; but with these, especially the rake angle, the selection is sensitive, as the force may be changed so as to be an exciting force, instead of a damping force, with respect to wheel wabble.

Though these damping forces are available, shimmy and tramp have persisted because the exciting forces dominated. This suggests that the evils should be overcome by reducing the magnitude of the excitation. In view of this, let us first consider the unbalance of the wheels and tires. This should be kept within reasonable limits, preferably at the lowest possible limit.

A second point of extreme importance is the steering geometry. All of the foregoing analysis is based on the supposition that any deflection of the chassis springs would cause no rotation of the wheel about its pivot because of errors in steering geometry. This is, of course, contrary to actual conditions in the conventional layout, in which the front spring is hinged at the front and shackled at the rear. With deflection of the spring, the path of the ball on the steering-knuckle gear-rod arm moves in an arc about the front eye of the front spring, conflicting with the arc of the steering-gear connecting-rod which it must follow if no displacement of the wheel on its pivot is to take place.

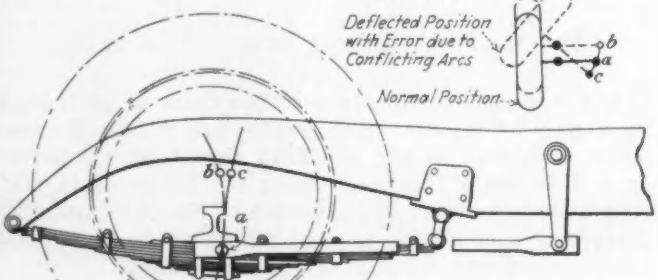


FIG. 12—EFFECT OF ERRORS IN STEERING GEOMETRY

Effect of Errors in Geometry

This condition is shown in Fig. 12. Since the ball cannot move along both arcs at the same time, there must be a movement of the wheel itself with the steering-gear remaining stationary, a movement of the gear while the wheel remains stationary with respect to the pivot, or a compromise movement of both. In any case, with the car running at speed, gyroscopic forces are immediately set up that are different than they would be if this error in geometry did not exist.

When the left front wheel passes over an obstruction that compresses both the tire and the left front spring, this error causes the following condition:

Due to the upward precession of the axle, the gyroscopic couple tends to turn the wheel from its straight-ahead position to a right-turning position. Analyzing the error in the geometry, we find that, with the ball

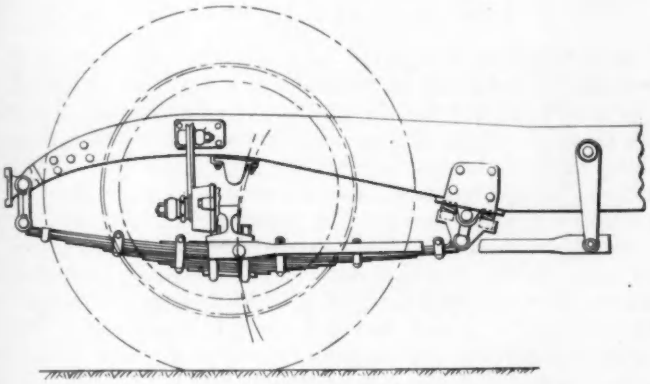


FIG. 13—LESS GEOMETRICAL ERROR WITH SPRINGS SHACKLED AT THE FRONT

tending to move along one arc and the steering-gear tending to move it along the other, any resistance in the steering-gear tends to turn the wheel in the same direction that the gyroscopic couple tends to turn it because of the upward precession. Therefore this error in steering geometry has a decided effect in accentuating the shimmy when it does begin, or in making it much easier for the shimmy to be started, because it has the effect of causing the wheels to rotate or wabble through a wider arc about the pivots when the gyrations are once started, thus greatly increasing the magnitude of the normal forces that tend to maintain the vibrations after they are started.

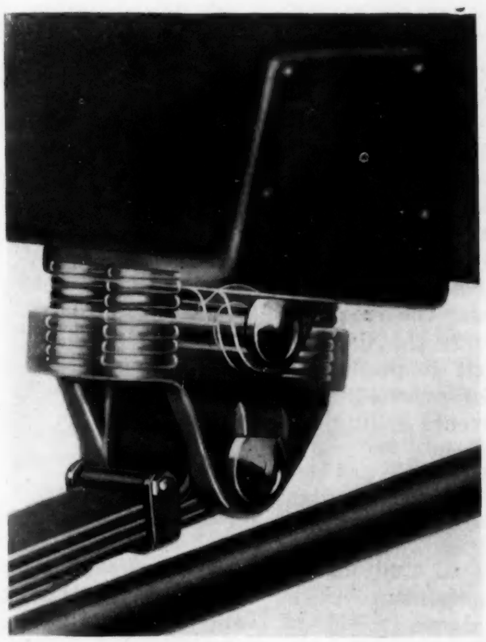


FIG. 14—CUSHIONED BRACKET AT THE REAR END OF THE LEFT FRONT SPRING

Theoretically, it is possible to have nearly perfect steering-geometry when the front springs are shackled at the front ends and thus, with the introduction of suitable damping forces, eliminate all possibility of shimmying; but, in practice, it is difficult to control damping forces and is practically impossible to make a steering system that is perfect as to geometry. However, the front-shackled spring goes a great way toward this end and makes possible perfect freedom from shimmying of the specially violent form which occurs at high speed, if the following precautions are observed:

(1) Carefully avoid resonance from unbalance of the front wheels, brake-drums and tires.

(2) Place balancing lugs on the wheels, so that the balance of the complete front-wheel assembly can be held within very close limits.

(3) Maintain sufficient damping forces between the frame and the axle, including friction between the leaves of the front spring and the action of shock-absorbers.

(4) Make the steering geometry as accurate as possible.

After the adoption of the front-shackled springs and the corrected steering-geometry by us two years ago, our success in combating the shimmy trouble was very gratifying. Complaints from shimmying were rare, but the control of the damping forces was somewhat sensitive. If the front springs were lubricated to the extent that they were very free acting, or if the shock-absorber setting became free, shimmy might be and generally was started when the car reached speeds at which resonance was partially established. However, one difficulty remained; the sharp wheel-kick in riding over obstructions was not eliminated or much reduced.

UTILIZING THE TROUBLESOME FORCE

A consideration of fundamentals indicates that a sound and rational solution of the problem of shimmy, tramp and wheel kick is theoretically possible. This is strongly suggested by the use of gyroscopes for steadying vessels at sea and for maintaining an upright equilibrium of monorail cars. In many respects the phenomenon of shimmy is almost analogous to the rolling of a ship at sea. In this analogy the motion of the axle is similar to the roll of the ship, and the wheels pivoted on the steering-knuckle spindles represent the gyrostats suspended in a pendulum, which in the case of the ship would be mounted with the axis of the pendulum horizontal and across the beam.

Such an undamped gyroscope mounted in a ship simply acts to increase the period of roll. Use is made, however, of the precessional relationship of the gyroscope to definitely damp the roll. This is done by applying damping forces to the pendulum carrying the gyrostat, so as to change the phase relationship of the precession of the pendulum with respect to the precession produced by the roll.

In the case of the front-axle sys-

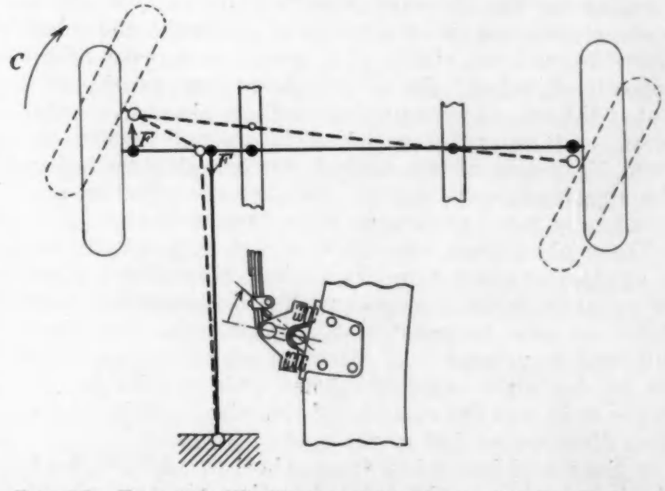


FIG. 15—EXAGGERATED REPRESENTATION OF REACTION WITH THE CUSHIONED BRACKET

tem, this would be exactly equivalent to applying friction to the knuckle pivots to delay the precession of the wheels; but this cannot be done, because any addition of friction at this point increases the effort of steering and is highly undesirable. The same object, however, can be accomplished by modifying the suspension with the front-spring eyes shackled, by adding a yieldable trunnion-bracket at the rear end of the left spring, as in the design shown in Figs. 13 and 14.

The function of the bracket is to permit the axle to move slightly fore and aft from its normal position under the influence of a gyroscopic couple acting through the trunnion but resisted by the friction of the steering-gear. The construction is such that any movement causes frictional damping forces in the bracket. Fig. 15 shows, greatly exaggerated, the movement of the axle under the influence of the gyroscopic couple set up by vertical inclination of the axle caused by road unevenness.

The couple *C* produces the forces, *F*, acting at the pivot and at the end of the steering-gear connecting-rod. If the friction of the steering-gear is sufficient, the connecting-rod to all intents and purposes is fixed on the steering-gear arm, the end of which does not move. The steering-knuckle gear-rod arm consequently pivots at the front end of the steering-gear connecting-rod, and in its rotation carries the axle to the position shown by the broken lines. Because of the tie-rod, the gyroscopic couples of both wheels always act together.

The effect of the resilience is to lower the frequency of the wheel system and, coupled with the damping forces due to friction in the bracket, it produces a damping effect to prevent shimmy in practically the same manner as a ship stabilizer prevents rolling.

Wheel Kick also Eliminated

Wheel kick is eliminated in a slightly different way, through the addition of another damping force created between the tire and the road. The tangential force due to striking an obstruction tends to move the axle back; that is, at the same time when the left wheel strikes the obstruction, the gyroscopic couple due to the upward precession of the axle tends to rotate the wheel to the right. This movement brings into play the reaction of the steering-gear connecting-rod, and the ball on the steering-gear arm acts then as a fulcrum so that the axle is urged forward, as indicated in Fig. 15. These two actions oppose each other by a phase difference of about 180 deg.; also, the forces on the end of the steering-gear connecting-rod oppose each other to such an extent that they are partly neutralized, and the wheel deflection is therefore reduced to a very small amount.

In this arrangement, the gyroscopic couple and the horizontal couple due to the tangential force are always proportional to each other, since both are proportional to the rate of rise of the wheel over the obstruction. It is not necessary for these two forces to completely neutralize each other; if the residual force is less than the friction in the steering-gear, no kick will be felt at the steering-wheel. This is easily proved by demonstration.

Front-end suspensions are not really so bad as some investigators have indicated; it is unnecessary to make any revolutionary changes to obtain the desired results. We are certain that, by the means we describe, even better results are obtainable than could be had previously with high-pressure tires.

THE DISCUSSION

H. A. Huebotter[3]:—For the purpose of studying the effect produced upon the steering mechanism by the tramping of the front axle, the model shown in Fig. 16, representing the right half of an axle assembly, was constructed. It is essentially a gyroscope, consisting of a wheel free to rotate about three mutually perpendicular axes, and it obeys the laws of precession that apply to the gyroscope. For example, with the wheel rotating in the forward direction, if an attempt is made to depress the right end of the axle, the wheel steers toward the right; if a torque is exerted in the opposite direction, the wheel steers toward the left. But if the axle is permitted to oscillate about the center pivot, and the rotating wheel is steered toward the right by means of the tie-rod, the wheel rises before the steering-knuckle turns. The reverse effect is produced by a force tending to steer toward the left.

These phenomena can all be stated in a simple rule of gyroscopic precession. If a wheel is revolving about its own axle and a torque is applied to rotate the wheel about an axis perpendicular to that axle, the wheel will tend to precess in a direction which, if continued for 90 deg., will bring the wheel axle parallel to the torque axis, and the rotation of the wheel will be in the same direction as that of the applied torque.

If the model had a left front wheel in addition, both wheels spinning in the same direction, the two wheels would precess alike and the effect would be doubled.

Extending the analysis to the motor-car, a torque applied to the axle center-member about an imaginary axis parallel to the length of the car will cause the wheels to steer either to the right or to the left. Such a torque is exerted by the two front springs when the axle is tramping. A sudden attempt to steer the car out of a straight forward direction tends to initiate tramping.

Precession in a gyroscope may also be induced without the application of an external torque. With the wheel of this model spinning in the forward direction and the axle rotating clockwise at a uniform velocity, the wheel would precess to steer the car to the right when the axle is in its normal position. Counter-clockwise rotation would steer toward the left. The torque that causes precession about the steering pivot is proportional to the product of the angular velocities of both the wheel and the axle.

Shimmy Initiated by Steering

Assume a car to be traveling at a high speed on a smooth road. The driver attempts to steer slightly to the right, but the gyroscopic stability of the front wheels resists such a movement, and the pull of the tie-rod about the steering pivot causes the right end of the axle to rise until checked by the opposing force of the springs. At this point steering toward the

[3] M.S.A.E.—Chief engineer, Butler Mfg. Co., Indianapolis.

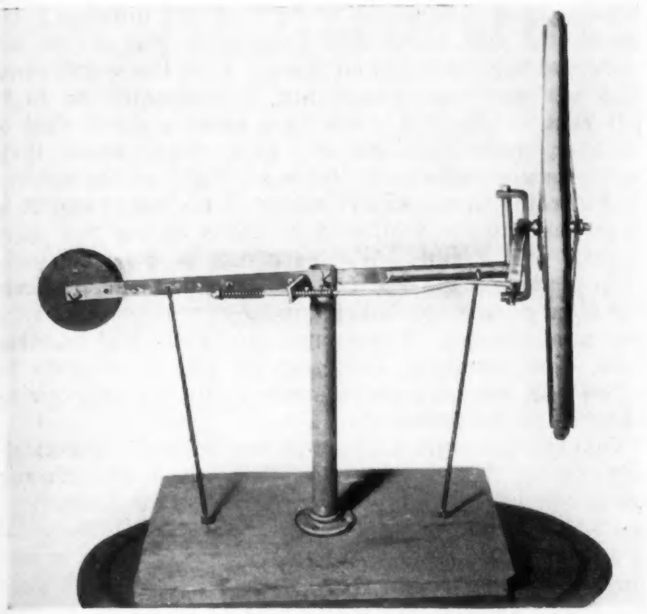


FIG. 16—GYROSCOPIC DEMONSTRATION MODEL OF FRONT AXLE

right is accomplished, because the clockwise torque on the assembly due to the springs causes both front wheels to precess toward the right, and this tendency is accentuated by the angular velocity of the axle as it tries to regain its normal position. Its inertia, however, carries it beyond the neutral point until the springs react with a counter-clockwise torque and swing the wheels to the left. Then front-wheel shimmy is in full progress, with its accompaniment of the tramping axle.

These are the external aspects of front-wheel shimmy, which can be reproduced in this gyroscopic model. The analysis does not, however, explain why shimmy continues in spite of the damping effects of the friction in the springs and tires. Such an explanation requires a study of the effect of road contact upon the instantaneous velocity of the wheels. In this study we may assume that the inertia of the car is so great that its forward speed is not affected by the angular position of the front wheels. In that case the rotational speed of the wheels must vary considerably during the cycle, because to the constant forward component is added a variable transverse component due to the oblique position of the wheels. Since the frequency of a shimmy cycle is in the neighborhood of 7½ cycles per sec., the wheel speed passes from the minimum to the maximum in about 1/30 sec. Even a small change in velocity at this high frequency corresponds to an acceleration of considerable magnitude. This acceleration is suggested as the dominating factor in the persistence of front-wheel shimmy, in the light of the following analysis.

Suppose the right end of the axle is swinging downward while the wheels are precessing to steer the car to the right. Accelerating the rotation of the wheel accelerates its precession. But we have seen that any attempt to hasten the precession of the wheels toward the right will cause the right end of the axle to rise. The force that produces this effect is supplied by the tractive effort of the driving wheels and is external to the gyroscopic system.

At first thought, it would seem that the upward force derived by trying to accelerate the precession during the clockwise oscillation of the axle would oppose that oscillation. It must be remembered, however, that the front axle is a freely vibrating mechanism in which all the acting forces are in tune with the natural frequency of the system. The forces are periodic, and their principal component probably is a simple harmonic, in which case the lag between the generation of the force and the influence the force exerts upon the system is about 90 deg. Hence, the force that is induced during the last half of the downward movement of the right wheel does not take effect until the beginning of the succeeding upward movement. At that time it adds its impulse to the rebound of the springs and, unless the damping factors are adequate, causes the shimmy to persist.

The analysis of this restoring force has covered only one-fourth of a cycle, but the other three-fourths behave in the same way. In view of the great tractive effort required between the road and the front wheels to produce the rapid wheel acceleration and deceleration, it is not difficult to understand why a car shimmies less on a wet than on a dry road surface.

The principal point this discussion has attempted to establish is that front-wheel shimmy is a natural consequence of the conventional axle design. So long as a heavy axle assembly is free to oscillate between soft springs and softer balloon-tires, the conditions are ideal for shimmy. Friction members may be introduced into the system to damp the vibrations, and flexible anchorages may be devised to throw the vibrations out of phase with the restoring forces, but the most direct way to cure the shimmy evil is to discard the axle center and to mount the wheels upon independently sprung supports.

EFFECT OF ROAD UNEVENNESS

W. R. GRISWOLD:—Mr. Huebotter has illustrated one of the many ways in which shimmy can be started. I believe unevenness of the road has a greater effect. As an illustration, assume a car traveling at 60 m.p.h., or 88 ft. per sec., going over a rise of ½ in. in a distance of 2 ft. This precession of ½ in. in 1/44 sec. gives an impulse more powerful than any other of the gyroscopic couples. However, other forces and couples act more or less in synchronism with this to maintain shimmy and wheel tramp.

A MEMBER:—Wheel wabble at low speed seems to be giving more difficulty, with the present steering devices, than the one that comes in at high speed. Steering-knuckle-pivot tilt may tend to correct the condition. When a wheel strikes a bump in the road, it tends to deflect to either the right or the left, depending on the amount of pivot tilt. Many times an overcorrection is transferred to the other wheel, especially if the steering-gear or its connecting-rod are loose. This can be corrected by reducing the pivot tilt.

MR. GRISWOLD:—We have had very little difficulty of that sort. With four-wheel brakes, the steering-knuckle pivot usually is inclined so that its extended axis intersects the gradient at the center of its contact with the tire. The reason for this is to limit any couple that might result from one brake having more pressure than the other, possibly causing the steering-wheel to be wrenched out of the driver's hand. This

pivot inclination raises the front of the car when the wheels are locked in either direction, and causes a tendency to keep the wheels in straight-head position.

Fore-and-aft rake gives a castering effect which adds to the self-centering effect, and any increase in the rake angle beyond about 2 or 3 deg. increases the restoring forces to considerable magnitudes so that, with any looseness in the steering-gear, or with a very free gear, wheel wabble will persist, because, when the restoring forces return the parts to central position, their inertia carries them past it. This condition causes wheel wabble without tramp, and that can be an exciting cause of shimmy when a car is going fast enough to cause gyroscopic forces sufficient to overcome the damping.

Virtue in Independently Sprung Wheels

F. F. Chandler[4]:—Never having driven cars with the patented damping device described in this paper, I do not know how effective it is. Shimmy and tramp occur at some time in almost every car that is being produced, and it seems impossible, with the conventional construction, to control the forces that cause them.

With conventional suspensions, there is rocking of the axle about a central fore-and-aft axis, which changes the angle of the wheel spindle and starts this aggravating precessional movement. Independent springing of the front wheels will restrict the spindle to parallel motion, so that road conditions cannot start gyroscopic action. The only exception is that an imperfection in the road has a slight tendency to rotate the steering-knuckle about its pivot, and that tends to produce tramp.

I believe that there is a great deal of virtue in independently springing the front wheels, and I hope some American engineer will experiment with this construction enough to demonstrate its value.

Chairman Earl G. Gunn[5]:—At the Paris Automobile Salon last year a number of cars with independently sprung wheels were exhibited, but I remember seeing only one or two this year. I asked a number of automobile dealers from various parts of the Continent why this construction seemed to be dying out; and they said that, while such cars did not shimmy, they rode so hard that the people did not buy them.

Stiff Frame the Basis for Cure

William Ernest England[6]:—Like everyone else, we have experienced trouble with shimmy, tramp, radiator wabble and excessive transmission movement. This year we came to the point where we have eliminated everything except wheel kick, even with a pressure of only 15 lb. per sq. in. in the front tires. This trouble has been serious in some cases and almost absent in others, even where we could find no difference between the two cars. We have tried the device Mr. Griswold has described on the car with the worst wheel kick we ever experienced, and it eliminated 85 to 90 per cent of the kick. We have spent a great deal of time on these problems and have talked about them with everyone who could throw any light on the subject.

According to our experience, it is useless to expect to cure the various front-end ailments unless you start with a stiff frame. Whatever else is done can only help matters. We use box-section side-members from the front spring-bracket to a point approximately at the center of the car. These must be rigidly tied together with cross-members and gussets, and care must be taken also in securely fastening the various spring hangers to the frame.

Our present rigid frame was worked out experimentally on a floor dynameter that gives the chassis rough treatment. It is surprising what contortions the whole assembly goes through and how little metal it takes in the right place to do wonders. It is also surprising to note how much so-called radiator-shimmy can result from a too flexible frame rear-end, as well as a flexible front-end. Although the rear of our engine is hung on vertical rubber-and-fabric discs and can be easily moved sidewise with a bar, we fit our transmission trim-plate with only 3/32 in. clearance all around.

Can Mr. Griswold tell us anything about experimental work, that I understand is being carried on by some concerns, in which the front springs are shackled at both ends and the front axle is provided with radius-rods parallel to the steering-gear connecting-rod?

Mr. Griswold:—I am not familiar with these experiments, but my opinion is that the construction described will not eliminate shimmy. The axle must be allowed some fore-and-aft freedom.

We experimented for a long while with the device we have described, and it is now in production. In our proving grounds we have some turns which are particularly effective in exciting shimmy. On these, we have been able without difficulty to cause tramp on every car tested without some auxiliary device. With the device described, regardless of speed, and with tire pressure as low as 15 lb. per sq. in., there was no sign of shimmy or wheel-tramp.

With a practically frictionless steering-gear, there will be some wheel kick; but with the steering-gear ratio needed in a car as heavy as ours, the friction is enough so that no wheel kick is felt even when riding over a safety-zone marker about 3 in. high and 12 in. in diameter at any speed within the range of the car.

It is difficult to conceive how any radical front-wheel suspension could accomplish results better than these, even though they possess other faults apparently much worse than those of conventional systems that do shimmy.

[4] M.S.A.E.—Vice-president, Ross Gear & Tool Co., Lafayette, Ind.

[5] M.S.A.E.—Chief engineer, Nash Motors Co., Racine, Wis.

[6] M.S.A.E.—Chief engineer, F. B. Stearns Co., Cleveland.

Chromium-Plating Progress

By W. M. Phillips[1] and M. F. Macaulay[2]

Annual Meeting Paper *Illustrated with* Photographs and Diagram

With the introduction of chromium-plated finish for the decorative parts of an automobile, chromium-plating progressed with great rapidity. In the early development work, it was possible to make satisfactory chromium-plating solutions by dissolving chromic acid in water with a small amount of chromium sulphate added, according to the authors. It was also found that the temperature and the current density used in plating are important factors, and that proper cleaning of the nickel surface is essential because, if the solution is too strongly alkaline, the chromium either deposits with iridescent blotches or as a gray burnt deposit, or else peels entirely. It is therefore necessary to do better polishing work on the base metal and better buffing work on the nickel surface.

Proper polishing is stated to be the secret of successful plating, because the ultimate finish is no better than the finish given to the base metal. To eliminate the polishing cost would decrease the total finishing-cost by about 75 per cent, the authors assert. This is the aim of all manufacturers, and they have met with success in some instances. One large company presses the part from highly polished steel, keeping the dies in such condition that no polishing is required after forming the piece.

In conclusion, the proper type of anode to be used in chromium-plating solutions is discussed. Inspection methods to make certain that a part has been chromium-plated completely are mentioned, and some uses of chromium-plating to reduce wear are listed.

In the discussion, an inspection bench which was developed to provide a satisfactory artificial light-source for use in inspecting chromium-plating is described. Light from a bank of "daylight" lamps, diffused through a white frosted-glass screen, makes the color differences between nickel-plating and chromium-plating stand out clearly. The subject of the formation of lead chromate on lead anodes is discussed, and an opinion is expressed that the formation of lead chromate is dependent upon how much current is being passed through a given cross-section of the anode.

After considerable experimentation, the Olds Motor Works started regular production of chromium-plating for decorative purposes in 1925. At the same time other divisions of the General Motors Corp. were developing chromium-plate as a resistant to wear on the surfaces of tools, gages and engine parts. With the introduction of chromium-plated finish for the decorative parts of an automobile, chromium-plating progressed with great rapidity. At the end of the next 15 months, the Hupp, the Oakland and the Studebaker companies were chromium-plating parts which formerly were nickel-plated. Today, every car manufacturer is ready to chromium-plate car parts.

In the early development work we were able to make satisfactory chromium-plating solutions by dissolving chromium anhydride, CrO_3, commercially termed "chromic acid," in water with a small amount of chromium sulphate added. The total content of sulphate should be about 1 per cent of the content of CrO_3, which ratio should be maintained approximately constant.

Owing to the relatively large content of impurities, consisting chiefly of sulphates, in our early supplies of commercial chromic acid, we found that the impurities in the bath soon reached such a concentration that no more parts could be plated with the solution. At one time we even decided to use chemically pure chromic acid, at a price of 74 cents per lb. Later, we were able to obtain, from various sources, commercial chromic-acid with a guaranteed purity of more than 98 per cent. The maintenance of the original sulphate content, however, proved to be only one of our troubles.

The temperature and current density used are exceedingly important factors. A suitable combination of these two, provided the part has been properly cleaned and that the plating solution is right, produces a hard, smooth deposit, with sufficient luster so that no buffing is required. Unless the underlying plate of nickel has been deposited from a slightly acid nickel-bath, all the nickel will be peeled from the part after $2\frac{1}{2}$ min. plating with chromium. We learned that thorough cleaning of the nickel is essential because, if the solution is too strongly alkaline, the chromium either deposits with iridescent blotches or as a gray burnt deposit, or else peels entirely.

The percentage of sulphate in the bath plays a very important part in the resulting plate, in regard to the color and to the throwing power, that is, its ability to plate into recesses. As a sulphate determination in the laboratory takes 12 hr., a production department would be in constant trouble if it had to wait for this analysis to be made. From the production viewpoint, the correction can be made in only one way; that is, by the trial-and-error method.

Constant Temperature and Current Density

The temperature and the current density must be maintained constant to obtain consistent results. Increasing the amount of current at the cathode produces a satin or matt finish, while raising it further will produce a flaky, burnt deposit. A bright plate is obtained only under certain conditions of temperature and current density. Since the temperature of all parts of the

[1] Works managers committee, factory production-engineering section, General Motors Corp., Detroit.

[2] Electrochemical engineer, Oakland Motor Car Co., Pontiac, Mich.

piece in the bath is the same, the parts getting low current-density at any one temperature may plate bright, but those getting high current-density may be burned. If the current-density is lowered by increasing the resistance or by lowering the voltage to decrease burning at the high-current-density areas or the protruding points, the low-current-density areas may not plate. From this it can be seen that an irregularly shaped object, or one containing holes or indentations, is difficult to plate. This is now partly overcome by shading the high-current-density areas with a screen and raising the current density sufficiently to plate in the low-density areas or recesses. Too high a temperature gives a bluish soft plate. All chromium-plating solutions are controlled by automatic thermal regulators which maintain the temperature constant within 2 deg.

A modern chromium-plating tank is shown in Fig. 1.

Unless the underlying nickel-plate is good, the money spent in chromium-plating goes for nothing; the nickel is very likely to peel after a minute or less of chromium-plating. To chromium-plate a piece less than 400 amp-min. with an efficiency of not less than 12 per cent seems to us to be slighting the job, because such a finish will not stand the polishing that some over-zealous car owners may give it. The only excuse for plating in less time is to obviate peeling the nickel, which, if properly plated, would not peel during 20 min. of chromium-plating. But it has been definitely proved by experimental tests that any plating for more than 500 amp-min. weakens, rather than improves, the chromium plate's resistance to rusting.

Proper polishing is the secret of successful plating, as the ultimate finish is no better than the finish given to the base metal. We decided that if we were ever to sell chromium-plate to the public we should have to do better polishing work on the base metal and better buffing work on the nickel. Roughness left in polishing is magnified by the chromium, giving the part a grayish appearance rather than the true blue-white of chromium, while poor nickel-buffing produces dull spots. To eliminate the polishing costs would decrease the total finishing-cost by about 75 per cent. This is the aim of all manufacturers, and they have met with success in some instances. One large company presses the parts from highly polished steel, keeping the dies in such condition that no polishing is required after forming the piece.

FIG. 1—RADIATOR SHELLS BEING CHROMIUM-PLATED IN A MODERN AUTOMATIC PLATING TANK

Great advance has been made in polishing methods through the adoption of automatic polishing-machines, and even greater accomplishments will be made in the coming years. Successful polishing, however, has its beginning in the drafting room, as the cost of polishing depends largely on the design of the piece. Wheels of very large diameter are more economical to use than wheels of small diameter. The part to be polished should be designed, therefore, to eliminate all unnecessary projections, depressions, angles, recesses or reverse curves, which can be polished only with narrow small wheels and at excessive cost. As the polishing department is the finishing department, the piece must be in good condition when it comes into the department. Dies should be kept in condition to eliminate scratches and deep marks.

Good polishing is dependent upon the absence of vibration. Manufacturers of polishing lathes have made great improvements during the last year in the design of these machines. Lathes are now driven through multiple V-belt drives by fully enclosed, ventilated motors. The spindle size has been substantially increased, and four 3/4-in.-diameter ball-bearings now take the place of the two 1/2-in. ball-bearings formerly used. As vibration greatly affects the finish and adds considerably to the fatigue of the operator, this is an important development. Each manufacturer has his own problems regarding polishing operations, but remarkable strides have been made in the last few years. The standardization of emery grain-sizes now being worked out by the General Motors Corp. and the abrasive manufacturers will mean much to the polishing industries. Then, and then only, will a grain manufacturer know that when he orders any certain size of grain he will receive that size.

The type of anode to be used in a chromium-plating solution has been the subject of much discussion. Chromium, iron, steel, lead, aluminum and various other anodes have been recommended as being best suited for regular production work. It was necessary to do considerable experimental work to find the most suitable anode to use to obtain the best results. We found chromium unsatisfactory, because it goes into solution and thereby increases the resistance. Aluminum also was unsatisfactory, as it is rapidly attacked by the plating bath. Lead and steel were both satisfactory; and the latter is more satisfactory, because it is the metal generally used for the tank and the tank can be made the anode. Lead, after being used as an anode on a production tank, is covered with a coating of lead chromate. This causes resistance to the flow of current and thus lowers the cathode efficiency. Considerable experimental work indicates that the type of steel best suited for use as an anode is one of low carbon-content, fully annealed. Alloy steels, such as silicon and chromium steels, are soluble and therefore are not as satisfactory.

Inspection by Color Difference

Thorough inspection of chromium-plating is important. The methods vary in different plants, but the main problem for the inspection department is how to make certain that the part has been chromium-plated completely. This can be determined in the laboratory by various methods. Two of the common methods are, first, to place the chromium-plated article in an acid copper-plating bath, where copper will deposit on all exposed nickel surfaces and will not deposit on the surfaces covered with chromium; and, second, to subject the piece to an atmosphere of hydrogen-sulphide gas in which all nickel surfaces will immediately show up black while the chromium remains unaffected.

But laboratory methods cannot be used for a production inspection. The only way the surface can be inspected for coverage is by visual inspection and, as this depends for its success largely upon the light used, it is important that the part be uniformly lighted so that the slight color-difference between nickel and chromium can be distinguished. Daylight is ideal, but most factories are constructed so that the use of daylight is impossible and it is necessary to use artificial light. The Society of Illuminating Engineers recommends that a half-cylinder, 18 in. long and 18 in. in diameter, painted flat-white inside, be suspended from the ceiling. The interior is lighted from a small trough, or cave, containing a 200-watt daylight lamp. The cut-off of the trough falls inside of the drum. The claim is that the slight color-difference between nickel and chromium can thus be detected.

Chromium-Plating To Reduce Wear

The use of chromium for mechanical applications has been growing rapidly. Today chromium is being used to plate such articles as plug gages, thread gages, snap gages, broaches and steady-rest rollers to give them greater resistance to wear. We have found that plating plug gages increases their life to at least three times that of an unplated gage. In the case of thread gages the life has been doubled. Broaches used to broach the babbitted end of connecting-rods have been chromium-plated, and we have been able to produce more than five times the number of rods per broach than can be produced with a regular production broach.

This branch of chromium-plating, as well as that for decorative purposes, is only in its infancy. Further uses for chromium appear daily. Some of the best electrochemical engineers in the Country are devoting their time almost entirely to solving the many problems of chromium-plating, about which we know very little. With the spirit of cooperation and friendly exchange of findings existing in the plating industry today, as contrasted with the secret art of but a few years ago, we hope to see a quick solution of many of the problems we do not now understand.

THE DISCUSSION

J. T. Caldwell[3]:—The inspection of chromium-plated parts involves a unique problem in illumination because it is necessary, not only to detect such defects as scratches and dents, common to all plating operations, but to detect areas which are not completely covered by chromium. Since a large percentage of chromium-plating is applied over nickel, it becomes necessary to take advantage of a slight difference between these two metals in their reflecting properties. Chromium reflects a higher percentage of blue light, and nickel reflects a higher percentage of yellow light.

The ideal light-source for chromium inspection is that of the blue north-sky, since it furnishes a well-diffused light containing no especially bright areas to cause glare and impair the vision of the inspector. The slight bluish tinge of light from this source serves to bring out the difference between nickel and chromium more sharply; and, incidentally, the dark lines of the window panes reflected from the metal offer an excellent means of detecting dents and irregularities in the contour of the parts inspected. Unfortunately, north-sky light of the proper color-value is not always available, and it is necessary to devise an artificial substitute.

Fig. 2 shows the inspection bench which was developed in our laboratory to provide a satisfactory artificial light-source. A bank of "daylight" blue Mazda lamps is placed above the front edge of the bench and properly housed to prevent the entrance of stray light. The light from these lamps is diffused through a white frosted-glass screen. This diffused light serves to illuminate a background painted with a flat-white paint and suitably shaped to reflect the light downward and forward upon the working plane. This gives a good substitute for north-sky light; the light is constant in color value and is available 24 hr. per day. If desired, a few horizontal or vertical black lines can be added to facilitate the inspection for dents and irregularities. The inspection position should be screened from any other light source that might interfere with and confuse the inspector.

Under such a lighting fixture, the color differences between nickel-plating and chromium-plating stand out clearly enough to permit ready detection of thin plating

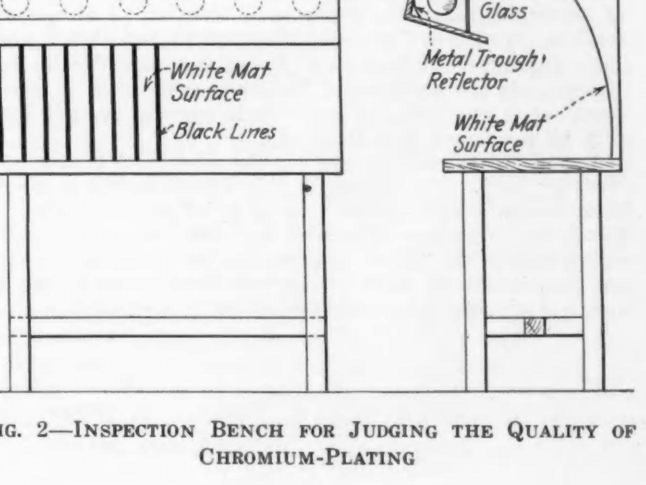


Fig. 2—Inspection Bench for Judging the Quality of Chromium-Plating

[3] A.S.A.E.—Sales engineer, Westinghouse Lamp Co., Detroit.

as well as voids in the chromium. Scratches appear as distinct black lines, as shown in Fig. 3. The advantages of this inspection apparatus are its simplicity of construction, its adaptability to either an inspection table or a moving belt, and the fact that its size can be varied according to the parts to be inspected.

QUESTION:—What success has been attained in chromium-plating zinc and white-metal die-castings?

W. M. PHILLIPS:—On door handles, radiator caps and other such die-castings, the practice is to nickel-plate them and then chromium-plate over the nickel.

QUESTION:—Is it necessary to copper-strike the die-casting before the nickel-plating is done, or can the nickel-plating be done directly on the die-casting?

MR. PHILLIPS:—That is to some extent a matter of opinion, but it is better to do the nickel-plating directly on the die-casting.

QUESTION:—What is the practice regarding the plating of die-cast aluminum?

MR. PHILLIPS:—Plated aluminum may be satisfactory for inside work, but I am opposed to plating aluminum that will be subjected to outside exposure. There is no difficulty in plating aluminum, but the plate does not seem to stand up satisfactorily when exposed to the weather.

LEAD CHROMATE ON ANODES

QUESTION:—What are the comparative costs of nickel-plating and chromium-plating the same article?

R. SCHNEIDEWIND[4]:—The percentage of rejections of chromium-plated articles is greater than that of nickel-plated articles. The cost for a copper-nickel-chromium-plated article is from 15 to 20 per cent greater.

Regarding the formation of lead chromate on lead anodes, my observation is that the chromate forms on the anode when the anode is too thin. For example, an

[4] Assistant investigator, department of engineering research, University of Michigan; consulting engineer, Detroit Plating Industries, Detroit.

FIG. 3—SCRATCHES AND DENTS IN CHROMIUM-PLATE MADE EVIDENT BY ARTIFICIAL LIGHT

anode 1/8 in. thick is not of sufficient size to conduct the current that is expected to go through it; therefore, it becomes hot and causes the formation of lead chromate. I have known anodes 1/4 in. thick to be in operation for three months without showing any trace of lead-chromate coating. In my opinion, the formation of lead chromate is dependent upon how much current is being passed through a given cross-section of the anode.

We hung some very heavy lead anodes in a tank and they would pit almost all the way through in three weeks when inert. As soon as they were connected anodically and a lead oxide formed, no further pitting was noticed. One company of which I know is considering the feasibility of short-circuiting the anodes so as to form a coating of chromium-lead oxide to prevent deterioration.

QUESTION:—Since the coefficient of thermal expansion of chromium is considerably higher than that of steel, and as chromium is rather brittle, how high a temperature can chromium-plated steel parts withstand before the chromium-plate begins to check and peel off of the base?

MR. PHILLIPS:—In one instance we tested chromium-plate that was about 0.001 in. thick up to 450 deg. fahr. and the plate did not peel.

Education in Production Economics

ECONOMICS of production presents a field that is as yet little developed. Much work has been done upon the somewhat restricted portion of this field that may be described as the finance of production as exemplified in the financial considerations that pertain to the design of a powerplant. But the application of the more general laws of economics, such for example as the law of diminishing returns, to the design and operation of industrial plants has not progressed very far. There is a considerable body of economic knowledge that has been reduced in a general way that is applicable to industry in specific ways if it can only be developed quantitatively.

At present these laws are for the most part known qualitatively only. Instruction in this group should cover the basic economic and manufacturing principles of modern industry as concerns industrial location, organization and management. It should present the economic significance and limitations of such aspects of industry as specialization, standardization, transfer of skill, division of labor and scientific management. It should also discuss the new economic problems that gather round such phenomena as quantity production, deferred-payment purchasing, ownership of stocks and bonds by people at large, and the more elusive problem of the circulation of money from employer to worker as wages and back as purchase money, etc.

The literature of this field is beginning to grow and no doubt the near future will see a great deal of attention given to this aspect of production. Competition alone will compel such a development. In general, also, this literature will and must emanate from the engineer and business man. The professional economist has not the intimate knowledge of the problem to be of much help in the matter. All engineering students who expect to enter the managerial side of industry, and there are many of them, should have some instruction of this character, and this instruction should be given by an engineering teacher or one very well informed concerning modern industry.—Dean Dexter S. Kimball, in *McGraw-Hill Book Notes.*

How the Ford Company Gets Low Production Costs

Discussion of John Younger's Production Meeting Paper[1]

ECONOMIC factors applying to mass production are dealt with in an endeavor to show how, by following certain laws of manufacturing management based on economic laws, the Ford Motor Co. has attained its very low production costs. Some of these laws, which were put into concrete form as recently as 1926 by L. P. Alford, are quoted, and examples of methods are given to show how they operate. Summarized briefly, the principles followed with obvious success are:

(1) Concentration upon a single product
(2) Keeping each article distinct
(3) Extensive use of conveyor systems
(4) Subdividing work so that each worker has only one or very few operations to perform
(5) Providing the required quantity of material of the specified quality at the required time and place
(6) Assigning a definite amount of work to each man to be done in a given time
(7) Wage payment on the straight day-rate
(8) Acquirement of sources of raw materials
(9) Reduction of inventories of materials in stock and in process
(10) Foregoing the taking of intermediate profits on processes between raw materials and finished product
(11) Keeping materials and parts in rapid motion to assure quick turnover
(12) Using machine-tools that give the lowest production cost and require the least manual control
(13) Employment of machines that perform several operations simultaneously with the same amount of labor as for one operation
(14) Sending machines to the overhaul shops at standardized periods
(15) Recognition that the obsolescence factor is more potent than depreciation of machines by wear

Discussers supplement the paper with numerous thoughts not mentioned by the author. The attainment of quality in a product, points out one, decreases cost in at least four ways, which he specifies. Another questions if the present trend toward making automatons of workmen is not fallacious and in direct opposition to the social trend of American civilization, which is in the direction of making men think. More extensive use of multiple-operation automatic machines is suggested as a possible remedy for this, and remarkable examples of such machines in other industries are cited. Regarding one of these, however, the chairman states that its successful development required 25 years, was very costly, and the product does not change in form, whereas design changes are frequent in the automotive industry. The last discusser calls attention to the importance of operating machinery continuously as many hours of the 24 per day as conditions render possible. He mentions the Ford company's policy of providing for production so that it will not be affected by such variables as weather and time of day, and of designing multi-story buildings to conform with production requirements and then providing artificial lighting of a kind that is superior to daylight.

HOWARD W. WELLES[2]:—One point at the very end of Mr. Younger's paper contains what is to me an interesting thought. It is the quotation from Mr. Alford's Laws of Management, "Control of quality decreases cost of production and makes economic mass-production possible."

Too often it is contended that to attain quality is to increase costs. As a matter of fact, the attainment of quality decreases costs in at least four ways: first, by affording the user greater satisfaction, thereby increasing the demand and making possible the economies of increased production; second, by the economies of assembly resulting from complete interchangeability of parts; third, by reduction of losses from defective material and workmanship; and, fourth, the economy in the operation itself resulting directly from the attainment of quality.

The last may not be the most important and has certainly received less comment than the others. Let me give a simple illustration. Suppose it is required to produce two holes in a piece of work. We may lay them out and drill them. Unless considerable care and time are used, the location of the holes will not be as accurate as is often required. To more easily attain the accuracy desired, a drill-jig may be used. The result is a better, faster, and cheaper job. How often does it occur that, when work is being turned out below the standard of quality, it is also taking longer than the standard time, and that when the conditions responsible for the increase in time are corrected, the quality standard is attained? How often, when more productive methods are employed, do we find a by-product in improved quality? Cases too numerous to mention will be recalled by each of us I am sure, and the point I want to bring out is that there is a fortunate relation between economy and quality.

[1] Published in the December, 1928, issue of the S.A.E. JOURNAL, p. 568. The author is president and editor of *Automotive Abstracts*, Columbus, Ohio, and is a Member of the Society. The abstract of the paper is reprinted herewith, supplemented by a summary of the accompanying discussion.

[2] M.S.A.E.—General superintendent, John Warren Watson Co., Philadelphia.

When you want to improve the economy, you will, if you go far enough, probably find that in so doing quality is improved. Raise the quality standard, and research and invention will develop a material, a method, a machine or a process which will be more economical.

Workmen's Operations Require No Thought

Norman G. Shidle[3]:—In connection with the question of day-rate as against the incentive systems of payment, I heard of an interesting experience last night which I think worth relating, because it tends to confirm the correctness of Mr. Younger's views, although I do not agree with the premise that the day-rate is ultimately the best method of payment.

A man who had been a college professor and also had had some industrial experience went out recently to work in a number of plants. He built up a considerable case record of experiences under various types of wage payment, among other things, and finally went to work at the Ford plant. After he had been there for some time, he became quite upset because, under the Ford system, it had taken him less than 6 hr., I believe he said, to learn his life work. He had only to give a nut two turns, I believe, and he felt contented!

The man who told me about it said that he asked this investigator, "Are you concerned because this contentment is upsetting your previously conceived theories of incentive payment, or because you find that you are just like everybody else?"

The ex-professor answered that he supposed it was because he found he was like everybody else. But he put it on this basis: That in the plants where he had been working under an incentive system he had found, both with himself and with his co-workers, a constant game between them and the management, the men trying to strike a rate at which they could earn the most money without resulting in having the rate cut, and the management trying to get them to do as much work as they could do, yet at the same time reducing the rate until eventually it represented what the management regarded as a fair earning power for the men. As a result, there was constant mental unrest on the part of the men. It put on them a sort of responsibility for thinking about their job and how much or how little work they would better do. He said that he found under the Ford system there was nothing like that; when the men went in they were told, "You will get $6 a day. You are not going to get any more, but you will not get any less. You need not worry about how much work you have to do, because the work will be there and it is predetermined. You do not have to think about anything.

Fundamental Fallacy of Present Trend

The ex-professor said that, far from resulting in overwork from high pressure, the Ford plan provides work of the easiest kind a man could do so far as effect on the nervous system is concerned. It was hard to learn the job, but it was not necessary to think about the work at all after the first day or two. He could stand all day long turning the nuts and think about anything he wanted to. Consequently, since apparently most men do not like to have personal responsibility of any kind, the system worked out very well in most cases from a psychological standpoint because it left them undisturbed and peaceful.

[3] A.S.A.E.—Directing editor, Chilton Class Journal Co., Philadelphia.

I was greatly interested in that, because it upset all my own preconceived ideas on the subject. This man, I understand, plans to write a book which will be published soon. What I have told is a second-hand quotation of what he found, and I shall want to read just what he says about it himself.

It seems to me, however, that possibly there is one fundamental fallacy in present production methods. Everything in connection with our educational and social civilization in the United States during the last 25 or 50 years has meant an increasing stimulation of the mind of the average man. The general level of education unquestionably has grown consistently during this period of years and the average worker has more education today than he had before. More newspapers and other printed matter are constantly coming to him, and, together with the radio, are bringing him new ideas that stimulate his thinking.

With all this social tendency to make the man's mind work more and more, it seems psychologically unsound to develop industrial systems that tend to make less thinking necessary. It seems to me that our tendency, in the long run, necessarily must be toward the development of an industrial system that will require more, rather than less, application of a man's mental activity; for example, by the adoption of more efficient and complex machines that require a higher degree of intelligence in their supervision and operation. That seems, from a broad, social, economic viewpoint, to be a sounder kind of development, because I think that we never shall get a satisfactory social economic set-up based on the idea that a man will merely exist as an unthinking machine for 8 hr. per day in an attempt really to live for 3 or 4 hr. per day. I believe that his work is an integral part of his life and must so continue; consequently, his work as well as his social life must involve factors that are in consonance with the general social mental growth which unquestionably has been going on.

System's Relation to Model and Market

One other thing I should like to say. Mr. Younger stated, in connection with the discussion of specialized versus standardized machines, that Mr. Ford has but one answer to this problem: "The machine that is less costly to operate, consideration being given to all phases of operation, is the one that he uses." I do not think that statement means very much. Does the qualifying phrase mean considering all *immediate* phases of operation or all future *potential* phases of operation, taking into consideration the necessity for model change in connection with market demand? That, it seems to me, is the important factor. I wish that we could hear from some Ford production man a real discussion of the economics of the Ford production system as related to the model and the market situation.

Mr. Ford's working-out of the production problem in conjunction with the change of model is the most interesting industrial experiment, I believe, that has gone on in the world for a long while. His past methods, it seems to me, did not facilitate the operation as Mr. Younger suggested, because it required more than a year to get into production on a new model. Some other companies shut down for about 30 days while making a change that, although not immediately so complete, was fully as complete compared with their models of two or three years ago; but they started making the changes a long while before. I should like to hear a lit-

tle discussion along that line from some of the Ford men.

CHAIRMAN ERIK OBERG[4]:—Perhaps the Program Committee may be able to arrange to have a complete paper on that subject from the Ford organization at a future meeting, and discussing from first-hand insight how these problems were solved and the real reasons for them.

DOES INDUSTRY USE ENOUGH AUTOMATIC MACHINES?

W. G. WALL[5]:—This is one of the most interesting papers we have heard for some time. It would be very interesting to have a detailed paper on each of the principles enunciated in Mr. Younger's paper. He certainly got the meat out of the cocoanut when he set down those principles so concisely and showed what they meant. It gives many of us an entirely new idea of certain types of production.

Mr. Welles referred to accurate work being more economical than rough work. That certainly is true where parts have to be assembled. We used to think that machining parts roughly was much cheaper than machining nicely, but we know that when parts have to be put together we save time and money in the end by accurate machine-work.

Mr. Shidle spoke of a man standing all day and turning a nut. Do we use as much automatic machinery in our motor-car industry as we can and should? Some of the allied industries use a great deal, but I have been wondering lately whether we use as much as we could economically use.

Recently I have seen three remarkable illustrations of automatic machinery. While this is just a little irrelevant, I shall tell about it. One was a cigar-making machine that gathers the fillers, which is a very simple operation, then picks up certain wrapper leaves and spreads them out and tests them for imperfections. If they are not perfect, electric apparatus indicates the fact. They then go through a number of processes, no one touching the tobacco in any way. The filler is rolled up and the wrapper put on. Different cams put on this machine give cigars of different shapes. The cigars as they come out of the machine are entirely finished.

Another one was a shell-loading machine which not only did a great deal to the shell itself but handled the fulminate and the powder, a rather dangerous process, all with one operation.

The third machine was, I thought, even more interesting. It was making 5-gal. glass carboys. This process used to require a large plant, but this particular glass company, which produces about 2,000,000 bottles a day, has this new machine for making the large carboys. The sand and other ingredients of the glass are fed by a chute into the furnace where they are melted. A large revolving part of the machine sucks up by vacuum a certain quantity of the liquid glass, pours it into a small mold and starts blowing air into the mold. Then the glass is changed automatically from the small mold into a large mold, which gives the carboy its final shape. Next it goes into another mold where it is annealed. All these molds have to be kept at high temperatures. When the carboy comes out, an inspector looks at it and it is placed in a crate. The whole process, from beginning to end, is controlled by two men.

These examples show what can be done by automatic machinery and raise the question: Is the motor-car industry taking advantage of as much automatic machinery as possible?

DESIGN CHANGES LIMIT AUTOMATIC-MACHINE USE

CHAIRMAN OBERG:—There is much suggestion for thought in what Colonel Wall has said. How far we can go profitably with automatic machinery is a big question. The reason the cigar company could go to the great expense and devote the necessary time in developing a successful cigar machine is that cigars remain the same. Tobacco of different qualities can be put into them, but they can be made by the same machine for 10 years to come and they will be all right. But to build automatic machines for making automobile parts would be a dangerous procedure, because car makers want to change their models, except that Ford, perhaps, will continue to build the new Model-A car for the next 10 years. It took 25 years to develop a successful cigar-making machine. The first machines, so far as I know, that were reasonably successful, and yet were not enough of a success to actually be used, were made by the Pratt & Whitney Co. in 1901. They were built on contract for the American Tobacco Co., which had its own designers and inspectors, the Pratt & Whitney Co. merely doing the work. To the best of my knowledge no cigar-making machines were sufficiently perfected to be used regularly until 1926, after 25 years of development work. There are few metal-working industries that could stand the expense and time of so long a development before reaching the successful application of the machine.

IMPORTANCE OF CONTINUOUS OPERATION

HERBERT CHASE[6]:—Mr. Younger has not been able to cover in his brief paper all the factors tending to reduce production cost in Ford plants. One of the important items which I do not find mentioned is that of keeping production equipment running continuously, as nearly 24 hr. per day as conditions permit.

Interest and depreciation charges continue to accumulate whether production machines are running or idle. Hence it is a recognized fact, but one too often lost sight of, that it pays to keep machines producing 24 hr. per day. This fact is not overlooked in the Ford plants. It is characteristic of the Ford organization, as of many other progressive concerns, that it does not allow such variables as weather or time of day to interfere with the steady march of production. Daylight, for example, though employed when available and where its use fits in with the production program, is not a primary consideration. There is no cramping of the program to make it conform to the vagaries of weather. Neither is there a moment's hesitation in building multiple-story structures because a single-story saw-tooth-roof building once was supposed to bring "ideal" lighting conditions for a part of each 24 hr. Ford buildings are designed to conform to production requirements, and provision then is made to assure adequate and good-seeing light without regard to weather, season, or time of day. The perfection of modern lighting-systems has made this policy possible and highly successful.

It is a noteworthy fact, for which physicists and illuminating engineers must be given credit, that they have not been content with providing illumination as good as daylight but actually have produced light which gives better seeing characteristics. I refer to light com-

[4] M.S.A.E.—Editor, *Machinery*, New York City.
[5] M.S.A.E.—Consulting engineer, Indianapolis.
[6] M.S.A.E.—Engineer, The Erickson Co., New York City.

posed chiefly of green and yellow rays, which, as Dr. Steinmetz[7] pointed out long ago, are highest in visual value and, because of their relatively low energy-content as compared with red rays so prominent in daylight, are easiest on the eyes. The Ford company is among the oldest and largest users of that kind of light (mercury vapor) in which green and yellow predominate while orange and red are absent.

The need for good lighting and its importance in relation to production may seem obvious, but concentration on other items frequently relegates them to secondary consideration. Then the whole production program suffers, and equipment which should be kept busy is allowed to remain idle during hours when it could be used to advantage if adequate light of the right kind were provided.

JOHN YOUNGER:—Referring to comments made by Mr. Shidle, it is often assumed that, because a man is unintelligent as regards his particular job, he is unintelligent at other things. This is not so. A man may know nothing about the machine on which he is performing work but be very intelligent as regards politics, religion or literature. Time spent at monotonous work at the machine often is employed by such men in thinking of diversions, as was the well-known case of the professor cited by Mr. Shidle.

[7] See Radiation, Light and Illumination, by Charles P. Steinmetz, Ph.D.

Why All This Mystery?

WHY all this mystery surrounding the matter of motor-car service-point capacities? Why do not motor-cars carry plainly stamped on them, at some easily accessible point, information which will permit filling stations to have exact information as to the capacities of the various gasoline, oil, water and grease reservoirs which they are called upon to service?

Is there some reason why oil filling-stations and the owners of the motor-cars themselves should not have available to them this important data?

Why not adopt a simple, sensible system of giving the public and the filling-station trade some light on this problem?

Why shouldn't motor-car manufacturers adopt a method of labeling capacities which will remove all guesswork and doubt as to the capacity of the gasoline tank, for instance?

—Or the radiator?

—Or the crankcase?

—Or the differential and the transmission?

Why the mystery?

Why keep the motor-car owners in the dark?

Why make it hard for the filling-station owner to do a good job in taking care of these complicated pieces of machinery which now fill the streets and the highways by the millions?

These are questions which are being put up to the manufacturers of motor-cars by *Petroleum Age*, which, in its January issue, initiated a campaign to throw some light on this problem.

Petroleum Age has for its objective in this effort the aim of making it a simpler, more efficient job to turn out good work at the filling station, to please and satisfy the filling-station's customers, who are the motorists, and to make the use of motor-cars a more care free, more pleasant and more inviting activity—ideas which presumably are behind the present sales and advertising campaigns of the motor-car manufacturers themselves in trying to sell always more and more motor-cars.

Petroleum Age believes the public is becoming fed up on the fact that this lack of intelligent information about the service-requirement quantities of their motor-cars is the only thing lacking to make the use of a motor-car a fool-proof, enjoyable and care-free activity.

The public should never be permitted to get the idea that there is something dark or mysterious or lacking about the information given them or given to those who serve them about the products which they buy and enjoy.

The service end of the automobile industry long ago left the stage where it could be sidetracked and pushed into the background. The matter of keeping motor-cars in mechanical repair and mechanical adjustment has become a problem of as much significance to motor-car manufacturers as has the problem of new-car sales, since it is only by keeping the owners of motor-cars satisfied with operation of their cars that the manufacturers can enjoy good-will and repeat business.

Why, then, should not the motor-car makers go a step farther to the logical conclusion of efficient service and make it as easy as possible for the motorist to receive motor fuel, lubrication and water service?

What *Petroleum Age* is advocating is this: A small plate, attached to the motor-car at some point easily reached, as under the hood. This would carry the information as follows:

Gasoline tank ....gal.
Crankcase ....qt.
Radiator ....qt.
Transmission ....lb.
Differential ....lb., etc.

The cost to the motor-car manufacturer for the plate and its installation on the new cars at the factory would be so small as to be negligible and need not enter into consideration. Apparently, the only question is, Would it be desirable for the motor-car owner and for those who serve the cars in use? To this apparently there can be but one answer—a favorable answer. The plate need be only a few square inches in size. It could be accepted as the final word and the last authority on these important questions. It would eliminate mistakes in servicing, overflows in filling tanks, and other incidents which, to say the least, do not improve the temper of motorists at some service stations.—*Petroleum Age*.

Motorcoach Maintenance

By Leonard Rose[1]

Cleveland Section Paper — *Illustrated with* Photographs and Forms

HEREIN the author points out, as a preface to a description of the preventive-maintenance system which he describes, that any system of maintenance is only as good as the men behind it and the honesty with which they use it. The personnel must be convinced that if the system is followed it will help the men to better themselves by pointing out their mistakes. The workers must be made to realize that the thing which really counts is not so much who made the mistake but what the mistake was and why it was made.

Daily, weekly and general inspections are practised in accordance with this preventive-maintenance policy, and details of the procedure with regard to records are given by the author. The company's repair and overhaul program is designed to eliminate guesswork to the greatest possible extent by providing instruments and standard testing-apparatus for determining the actual condition of the various motorcoach units both before and after repairs are made. An outline of the nature of the three classes of inspection is given, together with details of the shop organization, the major items of shop equipment and shop methods.

A well-balanced supply of repair parts is maintained, and the parts record-system is of the perpetual-inventory type. In the author's belief the fundamentals upon which the system is based can be applied with equal success to other types of motor-vehicle maintenance.

In the discussion the value of foremen's meetings is emphasized, and opinions on the subject of operating costs are given. Methods that tend to eliminate road testing are mentioned, and the practice of one company with regard to defective spark-plugs is stated.

ANY system of operation and maintenance is only as good as the men behind it and the honesty with which they use it. It may be a means of forming alibis but, if properly designed, it will be a means of detecting and thereby curbing them. The personnel must be convinced that the system, if followed, will help the workers to better themselves by pointing out their mistakes, and that the thing which really counts is not so much who made the mistake, but what it is and why it was made. I believe our organization is fairly well permeated with this idea. When a failure occurs, the employes make an honest effort to find out if something they did or failed to do contributed to or caused the failure.

The 58 double-deck 60-passenger motorcoaches of the type used in Cleveland weigh 21,000 lb. each. The gross weight with seated passengers is 30,000 lb. and, during the rush period with standees, 31,000 to 32,000 lb. The average speed during the heavy rush-hour period is 11 m.p.h. The coaches in city service operate approximately 30,000 miles per year, but the double-deck coaches average 35,000 miles annually, which represents three to four times the mileage of the motor-trucks used for city hauling.

We have three garages, two being termed operating garages, in which all motorcoaches are housed. The third is used solely as an overhaul station and central repair-parts storeroom. The garages operate on a 24-hr., and the overhaul station on a 9½-hr., basis. Each operating garage has two shifts under the supervision of two foremen. The day foreman has supervision of all maintenance activities in his garage and is held responsible for its successful operation. Major inspections and repairs are made by the day force. The night force, in addition to refueling and cleaning, makes only such repairs as may be necessary to provide sufficient coaches in safe operating condition to fulfill their schedules. A mechanical inspector is also assigned to each garage, and he acts as relief foreman.

Daily, weekly and general inspections are made. The general inspection is subdivided into A, B, C and D inspections. The A, B and C inspections are made at the operating garages; D is made at the overhaul station.

The transportation department places a defect report, Fig. 1, in each coach before it leaves the garage for service. This is designed to aid the driver in reporting to the mechanical department apparent defects in the coach by merely placing a cross in the square in front of the defective part and sometimes a descriptive word after the item. The reverse side is for remarks of the driver concerning the operation of the coach. The drivers turn in a report for each coach, whether a defect exists or not; the reports are turned over to the foreman by the dispatcher, and the foreman assigns the mechanics to make necessary repairs. Any defects that will not affect the safe operation of the coach are held over until the next inspection.

Defect reports are held in a pending file under the coach number until the work can be done. After making the repairs, the mechanic enters his clock number in the space provided; the report then goes to the foreman for his approval and is filed until a general inspection has been completed. In addition, each coach is given a minor inspection nightly; it can be made in a few minutes by an observant mechanic. This inspection was designed (see Fig. 2) to detect defects that may have been missed by the driver in his report. Only such repairs are made as are essential for safe uninterrupted service.

Organization for Repair Work

Our repair personnel is composed of inspectors and mechanics. The inspector merely makes the inspection and, through the foremen, issues instructions on regu-

[1] Assistant superintendent of motorcoach department, in charge of maintenance, The Cleveland Railway Co., Cleveland.

Form 1052 25M 8-13-28

THE CLEVELAND RAILWAY COMPANY
MOTOR COACH DEPARTMENT
MAINTENANCE DIVISION
DEFECT REPORT

Coach No.................... Date....................

Drivers' Names and No.'s
1. ....
2. ....
3. ....

DRIVERS CHECK THIS SIDE: USE OTHER SIDE FOR DETAILS

BODY	Mechanics No.	MOTOR	Mechanics No.
☐ Doors		☐ Ignition Switch	
☐ Windows (Give No.)		☐ Carburetor	
☐ Upper Deck		☐ Magneto Wiring	
☐ Lower Deck		☐ Water Pump	
☐ Roof		☐ Radiator	
☐ Floor		☐ Radiator Hose	
☐ Curtains		☐ Exhaust or Muffler	
☐ Seats		☐ Fan or Belt	
☐ Steps		☐ Throttle	
☐ Ventilators		☐ Hood or Hooks	
☐ Windshield		☐ Oil Pressure	
☐ Sash Locks		☐ Oil Leaks	
☐ Bumpers		☐ Batteries	
☐ Marker Lights		☐ Starter	
☐ Headlights		☐ Generator	
☐ Tail Lights		☐	
☐ Ceiling Lights		☐	
☐ Sign Lights		CHASSIS	
☐ Horn		☐ Steering	
☐ Signs		☐ Stiff	
☐ Heaters		☐ Loose	
☐ Mirror		☐ Wheels ☐ F ☐ R	
☐ Buzzer		☐ Axle ☐ F ☐ R	
☐ Fare Box		☐ Springs ☐ F ☐ R	
☐ Hand Rails		☐ Fenders ☐ F ☐ R	
☐		☐ Tires ☐ F ☐ R	
☐		☐ Brakes—Foot	
TRANSMISSION		☐ Brakes—Hand	
☐ Shift Lever		☐ Air Pressure	
☐ Clutch		☐ Hubs or Hub Bolts	
☐ Drive Shaft		☐ Gasoline Tank	
☐ Universal Joints		☐	
☐		☐	
☐		☐	
MOTOR		☐	
☐ Motor Knocks		All Defects Corrected	
☐ Motor Misfires			
☐ Motor Heats		O. K.'d By	

Mechanics Remarks: ....

Foreman's O. K.

LEAVE THIS TAG WITH DISPATCHER AT PULL-IN. (OVER)

FIG. 1—DEFECT REPORT REQUIRED FROM THE DRIVER OF EACH MOTORCOACH WHETHER OR NOT A DEFECT EXISTS

Form 1005 5m 1-27-28

THE CLEVELAND RAILWAY CO.
MOTOR COACH DEPARTMENT
MAINTENANCE DIVISION
INSPECTION AND LUBRICATION No. 1
DAILY AND SEMI-WEEKLY

Work Code
(A) Adjust (R) Repair
(N) Replace (T) Tighten
(P) Repack

Coach No. Date

Inspect		Remarks
1. Lamp Bulbs	O. K.	
2. Signals, Generator Output	O. K.	
3. Motor—Miss	O. K.	
4. Fan Belt, Compressor Drive	O. K.	
5. Water Pump	O. K.	
6. Magneto and Generator Coupling	O. K.	
7. Clutch Pedal Clearance	O. K.	
8. Windshield Wiper	O. K.	
9. Wheel Nuts and Bolts	O. K.	
10. Shock Absorbers	O. K.	
11. Bumpers and Fenders	O. K.	
12. Seats	O. K.	
13. Differentials Qts Oil........	O. K.	

Remarks ....

Coach ready for service....................

FIG. 2—FORM FOR MINOR INSPECTIONS MADE NIGHTLY TO ASCERTAIN DEFECTS THAT MAY NOT HAVE BEEN REPORTED BY THE DRIVER

lar forms to the mechanic who does the repair work. The term "inspection" refers only to the examination and tests made preliminary to making repairs. The number of inspectors is small.

The weekly inspection, Fig. 3, is primarily to secure adequate lubrication; in addition, the crankcase is drained and filled with new oil. Formerly done on a mileage basis, the present system of weekly changes of oil was adopted after we installed our oil-reclaiming unit. The cost of reclaiming oil is approximately 15 cents per gal., and we believe the additional cost of the more frequent changes is more than absorbed by the savings effected by better lubrication and simplified schedules. Coaches are assigned to regular days of the week for this inspection, and are placed in tripper service on the inspection day so that the work will not interfere with the transportation schedules.

The inspector, usually one of the best mechanics, indicates on the inspection blank by means of the "work code" shown at the top in Figs. 2 and 3 what repairs are necessary to the units shown. Any additional work is covered by a repair order (see Fig. 4) issued by the foreman. At this time work necessary as shown by the defect reports in the pending file is again given consideration and if, in the foreman's opinion, the work should be done, orders for it are issued on the repair order. However, if possible, this work is held over until the next general inspection.

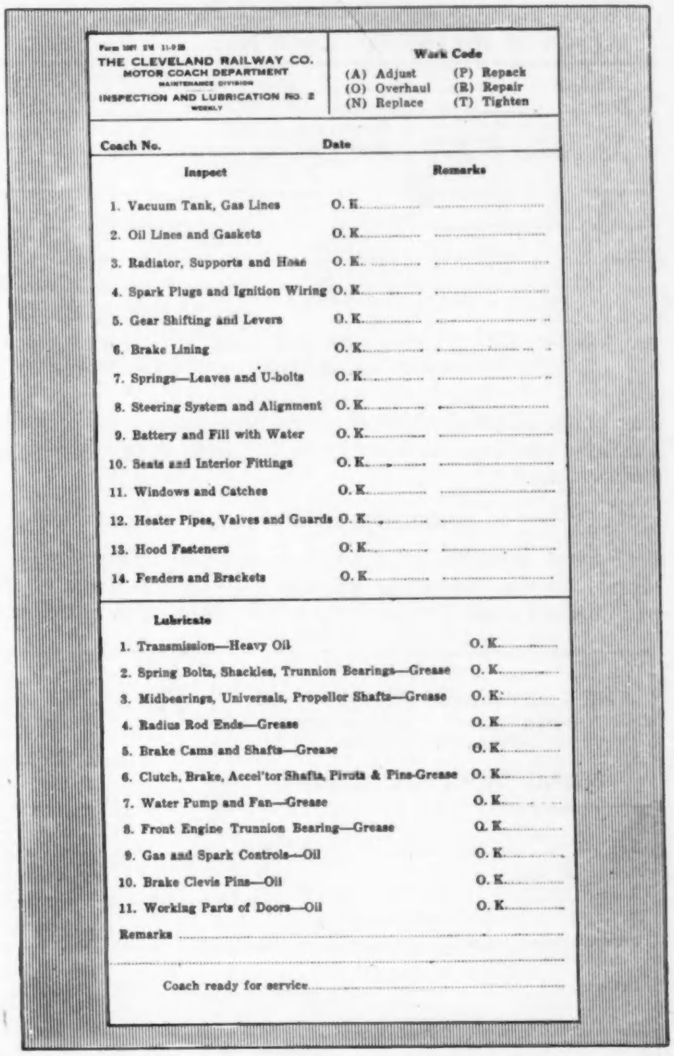
The purpose of the weekly inspection is to cover only such items as may require attention more frequently than is provided for by the general inspection. It also has the effect of bringing each coach definitely to the attention of the day foreman at comparatively frequent intervals, whether defects exist or not. Upon completion of inspections and repairs, the card is filed under the coach number until the next general inspection.

General Inspection To Anticipate Failures

The general inspection was designed to keep our coaches in good practicable "average standard condition," all things taken into consideration. Failures being a result of wear, and wear being proportional to miles operated, all other things being equal, I believe the "wear-out point" can be determined in terms of miles operated. With this thought in mind we attempted to build an inspection and repair schedule which would anticipate failures; therefore, we laid out a schedule of inspections based on mileage. Considering that different units, because of their limitations in design, have a wide difference in mileage life, we believe our schedule was a very good compromise. These schedules have been revised several times, and the mileage trend has been in the right direction.

The schedule of inspection and repair is now in the process of being remodeled. I am convinced that it will not only increase our standard of condition but will lower our cost per mile. This has been made possible because equipment and design have been improved, the efficiency of our operating and maintenance forces has increased, and our knowledge has been augmented by the data from our system of records. For example, our original schedule included an inspection of main and connecting-rod bearings together with the replacement of piston-rings and piston-pins every 15,000 miles, with a general overhaul at 50,000 miles. The bearing take-up inspection was next set at 20,000 miles and then at 25,000 miles, with the overhaul period still at 50,000 miles. Recently we have decided to increase these mileage intervals to 35,000 and 70,000 miles respectively. I have no doubt that operation under this schedule will equal that of the earlier schedule. Some units of the coach require more frequent overhauling, and that is what our system sets out to accomplish.

Operating conditions vary for different localities and types of service, and no schedule of inspections could be devised that would fit all service as a whole; but a schedule can be devised that, with a reasonable amount of interpretation, can be made to fit generally. While the schedule I am about to give differs in many details from



THE CLEVELAND RAILWAY CO.
MOTOR COACH DEPARTMENT
MAINTENANCE DIVISION
INSPECTION AND LUBRICATION NO. 2
WEEKLY

Work Code
(A) Adjust (P) Repack
(O) Overhaul (R) Repair
(N) Replace (T) Tighten

Coach No. Date

Inspect — Remarks

1. Vacuum Tank, Gas Lines O. K.
2. Oil Lines and Gaskets O. K.
3. Radiator, Supports and Hose O. K.
4. Spark Plugs and Ignition Wiring O. K.
5. Gear Shifting and Levers O. K.
6. Brake Lining O. K.
7. Springs—Leaves and U-bolts O. K.
8. Steering System and Alignment O. K.
9. Battery and Fill with Water O. K.
10. Seats and Interior Fittings O. K.
11. Windows and Catches O. K.
12. Heater Pipes, Valves and Guards O. K.
13. Hood Fasteners O. K.
14. Fenders and Brackets O. K.

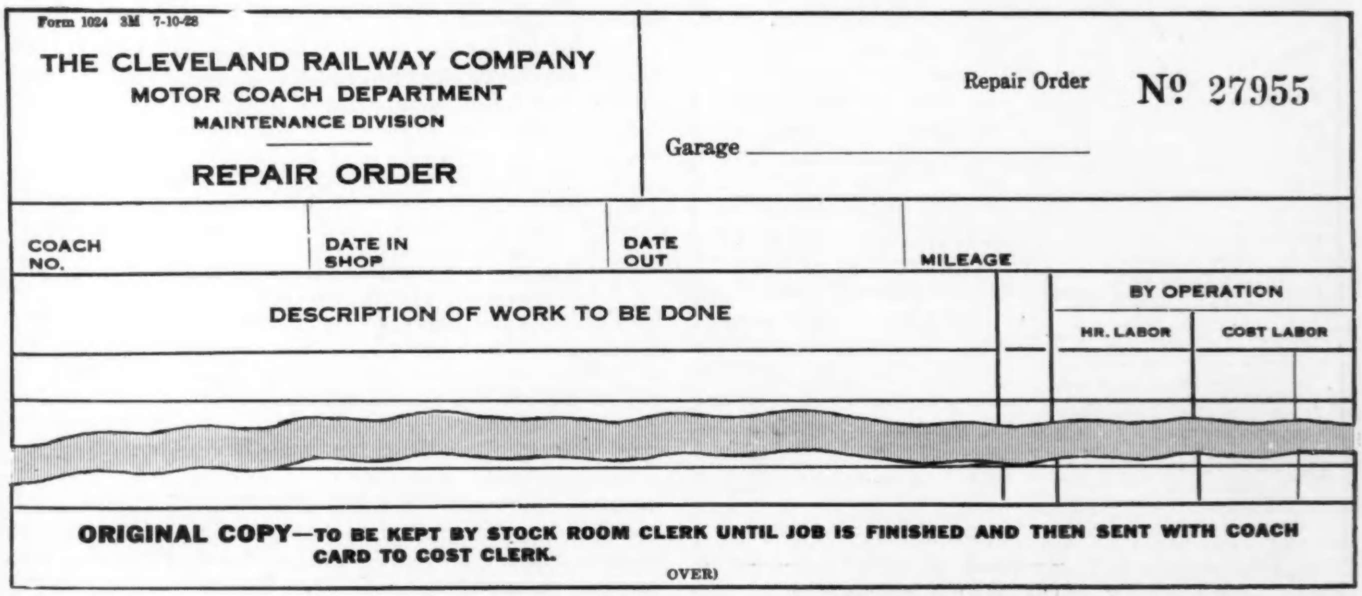
Lubricate

1. Transmission—Heavy Oil O. K.
2. Spring Bolts, Shackles, Trunnion Bearings—Grease O. K.
3. Midbearings, Universals, Propellor Shafts—Grease O. K.
4. Radius Rod Ends—Grease O. K.
5. Brake Cams and Shafts—Grease O. K.
6. Clutch, Brake, Accel'tor Shafts, Pivots & Pins-Grease O. K.
7. Water Pump and Fan—Grease O. K.
8. Front Engine Trunnion Bearing—Grease O. K.
9. Gas and Spark Controls—Oil O. K.
10. Brake Clevis Pins—Oil O. K.
11. Working Parts of Doors—Oil O. K.

Remarks

Coach ready for service

Fig. 3—Form for Weekly Inspection Made Primarily to Secure Adequate Lubrication; in Addition, the Crankcase Is Drained and Filled with New Oil



Form 1024 3M 7-10-28

THE CLEVELAND RAILWAY COMPANY
MOTOR COACH DEPARTMENT
MAINTENANCE DIVISION
REPAIR ORDER

Repair Order Nº 27955

Garage

COACH NO. | DATE IN SHOP | DATE OUT | MILEAGE

DESCRIPTION OF WORK TO BE DONE | BY OPERATION: HR. LABOR | COST LABOR

ORIGINAL COPY—TO BE KEPT BY STOCK ROOM CLERK UNTIL JOB IS FINISHED AND THEN SENT WITH COACH CARD TO COST CLERK.

OVER)

Fig. 4—Repair Order Issued by the Foreman to the Mechanics

Form 1057 1M THE CLEVELAND RAILWAY CO.

RECORD OF REPAIRS TO COACH NO.______ FROM__________192__ TO__________192__ First Mileage__________ Last Mileage__________

Make and Type | Date Delivered | OPERATION CODE [A] Adjust [I] Inspected & O.K. [N] Replaced [O] Overhauled [R] Repaired [T] Tighten | Garage Repairs in Black Ink, Road Repairs in Red Ink, General Inspection in Green Ink

DATE	MILEAGE	REPAIR ORDER NO.	POWER PLANT Engine, Transmission, Clutch, Carburetor, Radiator, Fan, Exhaust Pipe, Front Motor Support	CHASSIS Frame, Rear Axle, Differentials, Front Axle, Steering, Universal Joints, Wheels Propeller Shafts	BRAKE EQUIPMENT Shoe, Drums, Linings, Brake Mechanism, Compressor, Control Valves and Air Lines	ELECTRICAL SYSTEM Battery, Generator, Starting Motor, Horn, Magneto, Spark Plugs, Chassis Lights and Wiring	BODY Paint, Upholstery, Doors, Windows, Body Parts, Body Lights and Wiring

FIG. 5—REPAIR RECORD OR COACH-HISTORY CHART

Entries Are Made in Green, Red, and Black Ink According to the Nature of the Repair. This Facilitates the Determination of the Efficiency of the Vehicle and Makes It Possible To Trace the Mechanic Who Did the Repair Work

our original plan, basically it is the same, and so will the new one be. It illustrates the idea of progressive inspections.

INSPECTION PROCEDURE

General inspections are made by the inspector assigned at the operating garage and include usually a preliminary road-test, a study of the defects as noted on the drivers' defect reports being held pending, and a pit inspection. The inspector is guided by a list of the various items which should be inspected for possible repairs. From the information gathered during this inspection he writes a repair order, giving definite instructions to the mechanics regarding repairs to be made. To these findings he adds the predetermined repairs called for by the class of inspections he is making.

Form 1058 5M Sets 5-17-28

THE CLEVELAND RAILWAY CO.
MOTOR COACH DEPARTMENT
MAINTENANCE DIVISION

ROAD SERVICE ORDER

R 5151

Garage ....
Date ....

Run No.................... Coach No....................

Route....................

Reported from....................

Driver.................... Time....................

SERVICE AT

Location....................

Time....................

Direction....................

Time O. K.......... Delay.......... Miles Lost..........

Remarks....................

Dispatcher....................

Trouble Reported....................

Repairs Made....................

Road Mechanic Number

Foreman's O. K.

FIG. 6—ROAD-SERVICE ORDER WHICH ORIGINATES IN THE DISPATCHER'S OFFICE

The general inspection being designated as Class 3, the four groups in this class are called 3A, 3B, 3C and 3D. Inspections are made after each specified period of operation and include the following items:

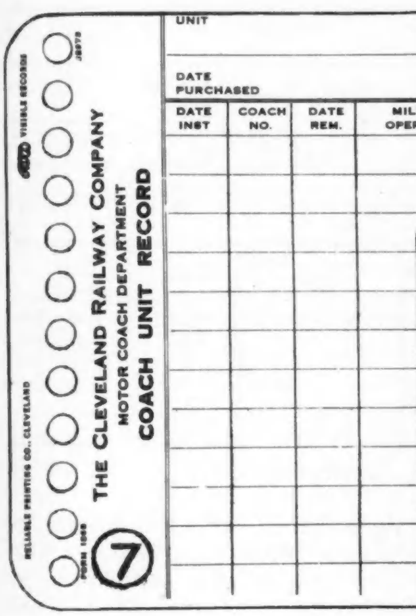
Class 3A, after 2500 miles
- Clean carbureter wells and screens
- Drain vacuum tank and sediment bowl of gasoline tank
- Clean brake-linings
- Clean oil-filters
- Clean magneto distributor-head
- Clean generator commutator
- Lubricate all wheel bearings with grease
- On White coaches drain the clutch, wash with 1 pt. of kerosene and refill with 1 pt. of light engine-oil
- On Safeway coaches grease the clutch, the throw-out bearing and the pilot bearing; oil the torque tube; and replace the C-2 valve with an overhauled unit

Class 3B, after 5000 miles
- Inspect the same as for Class 3A and, in addition:
- Wash out the transmission case and refill
- Wash out the differential case and refill

Class 3C, after 15,000 miles
- Inspect the same as for Class 3B and, in addition:
- Clean out carbon and grind valves if necessary
- Wash the radiator and the cooling system with cleaning solution and replace the hose connections as necessary
- Replace with overhauled units the magneto, the generator, the starter, the air-compressor and the B-4 air-valves

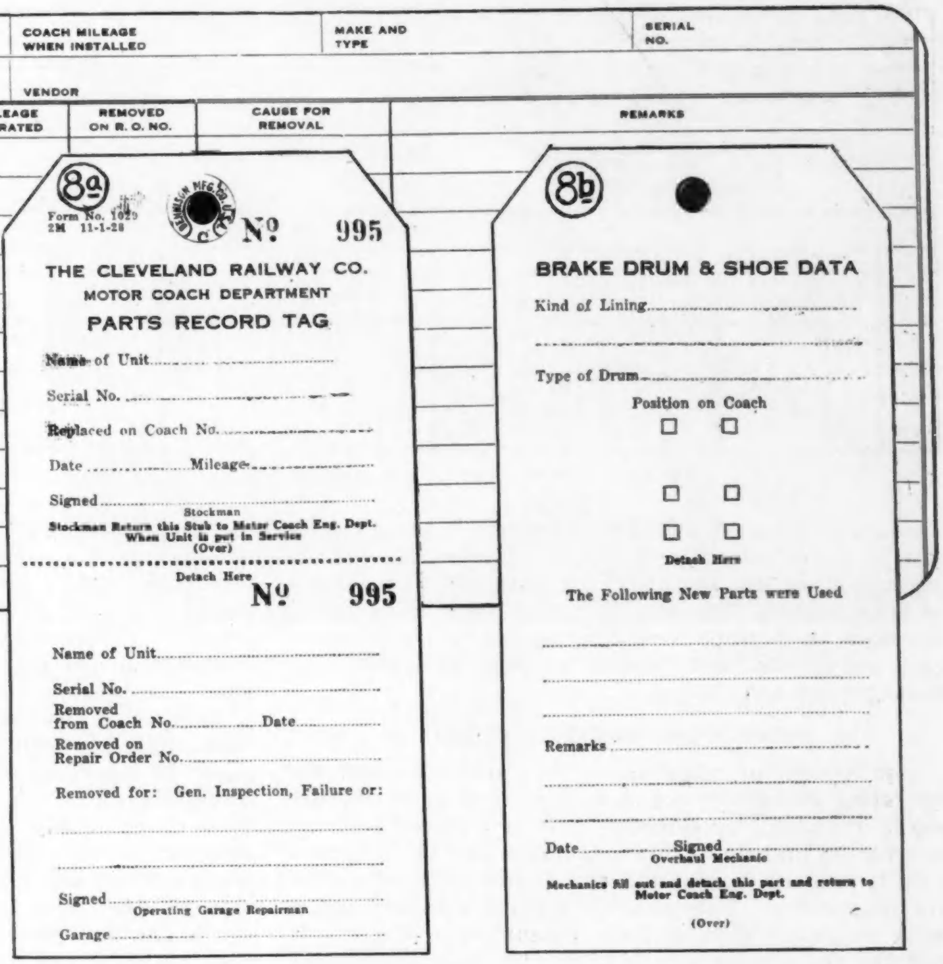
Class 3D, after 35,000 miles
- Inspect the same as for Class 3C and, in addition:
- Adjust the crankshaft and the connecting-rod bearings
- Replace the piston-pins and the bushings as necessary
- Replace the piston-rings as necessary

Our system of maintenance, including costs and permanent records, is built around the repair order, Fig. 4, which is made in duplicate. The carbon copy, being instructions to the shop, is of cardboard, and is placed



THE CLEVELAND RAILWAY COMPANY
MOTOR COACH DEPARTMENT
COACH UNIT RECORD
7

UNIT				COACH MILEAGE WHEN INSTALLED		MAKE AND TYPE	SERIAL NO.
DATE PURCHASED				VENDOR			
DATE INST	COACH NO.	DATE REM.	MILEAGE OPERATED	REMOVED ON R. O. NO.	CAUSE FOR REMOVAL	REMARKS	



8a
Form No. 1029
2M 11-1-28
Nº 995
THE CLEVELAND RAILWAY CO.
MOTOR COACH DEPARTMENT
PARTS RECORD TAG
Name of Unit..........
Serial No. ....
Replaced on Coach No. ....
Date .... Mileage..........
Signed.......... Stockman
Stockman Return this Stub to Motor Coach Eng. Dept. When Unit is put in Service
(Over)
Detach Here
Nº 995
Name of Unit..........
Serial No. ....
Removed from Coach No. .... Date..........
Removed on Repair Order No. ....
Removed for: Gen. Inspection, Failure or:
Signed.......... Operating Garage Repairman
Garage..........

8b
BRAKE DRUM & SHOE DATA
Kind of Lining..........
Type of Drum..........
Position on Coach
Detach Here
The Following New Parts were Used
Remarks ....
Date.......... Signed.......... Overhaul Mechanic
Mechanics fill out and detach this part and return to Motor Coach Eng. Dept.
(Over)

FIG. 7—FORM USED FOR EACH MOTORCOACH TO MAKE EASILY ACCESSIBLE ALL NEEDED INFORMATION CONCERNING IT

FIG. 8—PARTS RECORD-TAG COMPRISING ALSO BRAKE-DRUM AND BRAKE-SHOE DATA

in a celluloid-faced envelope and hung on the coach. The original copy goes to the stockroom, where it serves as authority for the issuance of repair parts and remains until the work has been completed. A space is provided for the mechanic's number, to indicate for what work he is responsible. All labor performed in the shop is charged to a repair order through the medium of clock cards; materials are charged to it by means of the stock requisition.

When repairs have been completed, the cardboard copy of the repair order is filed in the foreman's office according to coach number. Before filing, the clerk makes brief entries of the repairs on an individual-coach repair-record card, Fig. 5. The entry covers the date, mileage, repair-order number and the unit repaired. For brevity, the standard code shown is used. Entries are made in one of three different colors, depending on the nature of the repairs. Green entries cover scheduled inspections; black, repairs made between regular scheduled inspections; and red, failures or road calls. To isolate these road calls, a separate road-call-service order, Fig. 6, is furnished; it originates in the dispatcher's office.

The foregoing orders are summarized monthly on a mileage basis according to garages, fleets and units. The average mileage between road calls indicates the efficiency of our inspection program. The results obtained from arranging the summary according to units and garages makes it possible for a foreman to compare the results of his own operations with those of a like operation. They point out to him his weak points and the part of his work on which he should concentrate. This continually sets up new and higher standards for the men and the foremen.

Referring to Fig. 5, which we call the coach-history chart, it will be seen that, by recording repairs according to the major units and by the use of different colored inks, a good idea of the individual-coach performance can be had at a glance. If the coach were operating at 100-per cent efficiency, nothing but green ink would appear on the chart. Entries in black or red ink show a loss of efficiency, and the unit responsible is immediately apparent. A most important feature is that the individual responsible for the loss of efficiency

F-1027 500 7-19-28
THE CLEVELAND RAILWAY CO.
MOTOR COACH DEPT.
DEFECTIVE MATERIAL INSPECTION TAG
Date
Part Name
Serial or Part No.
Removed From
Reason for Removal
Disposal
Returned Goods Memorandum No.
Inspector

FIG. 9—TAG FOR ATTACHMENT TO DEFECTIVE PARTS OR UNITS

Form [illegible]

THE CLEVELAND RAILWAY COMPANY
MOTOR COACH DEPARTMENT
MAINTENANCE DIVISION

DAILY FUEL AND LUBRICANT DISBURSEMENT

Garage			Date	
PUMP READING	Start	R. M. Reading	Finish	
Gas. Meter No. 1				Receipts: Gasoline ____ Oil ____
Gas Meter No. 2				Inventory: Gasoline ____ Oil ____
Engine Oil				

All Readings Must be Taken as Directed

REMARKS

COACH	GARAGE Gas			GARAGE Engine Oil		TOTAL		COACH	GARAGE GAS			GARAGE Engine Oil		TOTAL		COACH	GARAGE GAS			GARAGE Engine Oil		TOTAL	
	Gal.	Gal.	Gal.	Qts.	Qts.	Gas	Oil		Gal.	Gal.	Gal.	Qts.	Qts.	Gas	Oil		Gal.	Gal.	Gal.	Qts.	Qts.	Gas	Oil
100								163								500							
101								164								501							
102								165								502							
103								166								503							

Fig. 10—Work Sheet Used for Recording Gasoline and Oil Consumption

can be and is traced, and is thus assisted to avoid a repetition of errors. The responsible person may be the manufacturer, the inspector, the foreman, the mechanic or even myself. Statistics obtained from these forms are made up in graph form monthly for future reference and comparison, and become an important factor of management and control.

Unit Replacement Practised

Our system of maintenance is planned so that the operating garages do not make repairs to units that are easily replaced. A defective unit is replaced with an overhauled unit when this is possible, and the defective unit is properly tagged and sent to the overhaul station for disposition. This practice assures standardization with maximum economy; the consumption of parts is low and the salvage rate is high. To facilitate the operation of this plan, replacement units are set up in advance of the requirements whenever possible. The replacement stock includes such units as engines, magnetos, carbureters, destination signs, seats, window frames, differentials, transmissions, steering-posts, brake-drum and hub assemblies, propeller-shafts, axle-shaft and bearing assemblies, and the like.

Records of performance of the more important of these units are kept at the overhaul station. To simplify the recording of this information and to make it accessible, we use visible loose-leaf record sheets, of the form shown in Fig. 7, in sets of two, the pair being of different colors. The sheets are set up according to coach number and form an inventory of coaches in service, together with the serial numbers of the units of which they are constituted. These sheets give a complete history of the coach and all its units from the time

Form 1060 1M 9-11-28

THE CLEVELAND RAILWAY CO.
MOTOR COACH DEPARTMENT
DAILY RECORD—MILEAGE, GAS, OIL

COACH No. ....

MONTH OF ....

DATE	TOTAL MILEAGE	1	2	3	4	5	6	7	8	9	10	11	12	13	Outside Gas Gal.	Cyl. Oil Qts.	Gar. Gas. Gal.
1																	
2																	
30																	
31																	
Totals																	
Gals. Gas per Route																	
Qts. Cyl. Oil per Route																	
Average Miles per Gal. Gas																	
Average Miles per Qt. Cyl. Oil																	

Fig. 11—Sheet for Recording Mileage Statistics and Disbursements of Gasoline and Oil. One of These Sheets Is Provided for Each Motorcoach

they are placed in service until they are discarded. Information for this file is obtained from a system of tagging the units, as shown in Figs. 8 and 9.

The operating garage which removes the unit places on it a linen tag, Fig. 8, giving the information called for. The tag is perforated across the middle. The upper half of the face of the tag is left blank, except for the name and serial number. The part so tagged is sent to the overhaul station where it is either repaired or scrapped. When repairs have been completed, the lower half of the card is filled in on the back with details of the repairs made, and this half of the card is sent to the engineering division, where the information is transferred to the units record. The repaired unit is then sent to the operating-garage stockroom. When it in turn replaces another unit, the rest of the information called for by the upper half of the tag, such as coach number, date, mileage of the coach and, in the case of the brake-drums or brake-shoes, the kind of lining, type of drum and wheel location, is noted on the reverse side. The stockman signs this card in the space provided, forwarding it to the engineering department so that the unit-record book can be posted to date. Complete information on tested units can readily be obtained from this system.

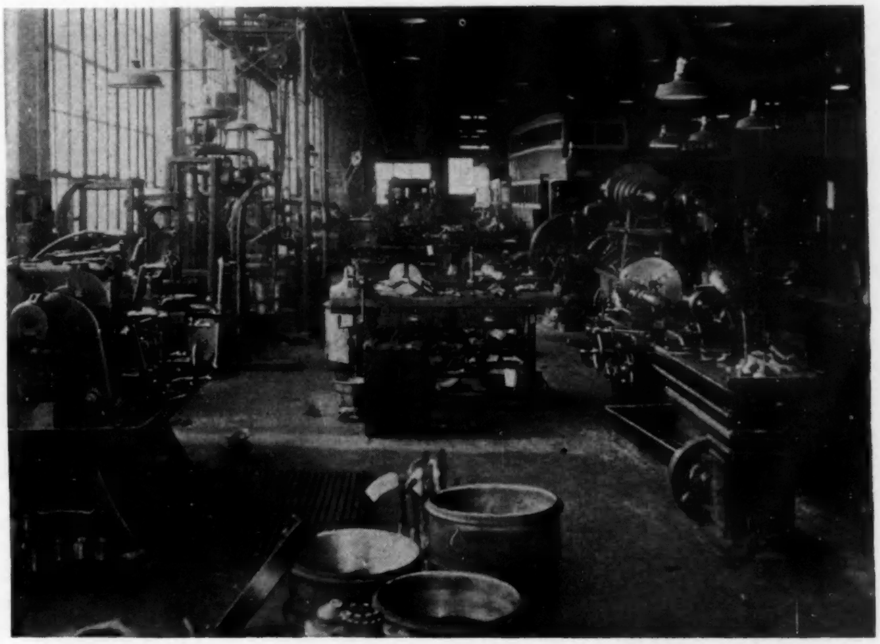


Fig. 12—General View of the Overhaul-Garage Machine-Shop

If the operating-station foreman should decide from the information that the unit failed because of a defect, the unit or part is tagged with a defective-material inspection tag, Fig. 9. Such information as the date, the part name, the serial number, the unit from which it was removed and the reason for its removal, is given, and the part is sent to the overhaul-station storeroom, where it is inspected by the foreman and disposition of it is made. Such parts come to my attention when there is any doubt as to their proper disposition. If we decide that we are entitled to a replacement from the manufacturer, the part is returned to its original source

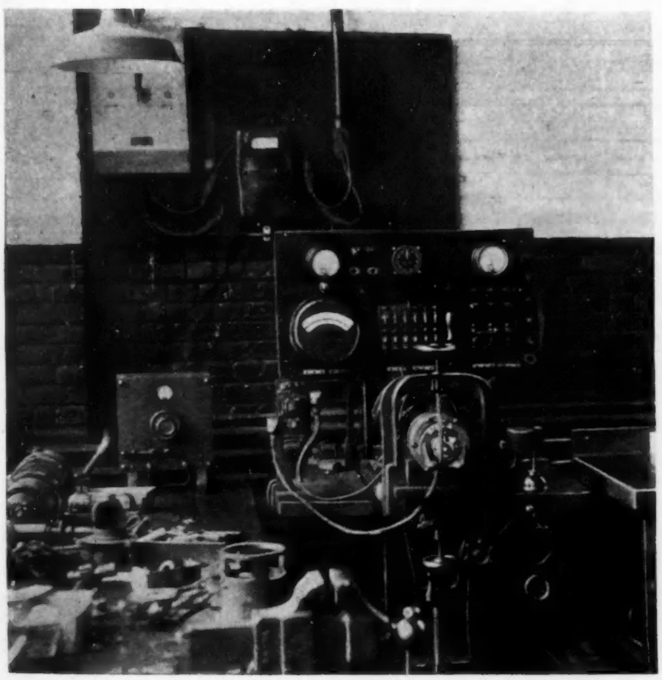


Fig. 13—Electrical Section of the Machine-Shop

Standard Electrical Tests Are Made with Suitable Apparatus. After Repairs Are Made, the Unit Is Operated Normally To Determine Whether Its Performance Conforms with the Standard

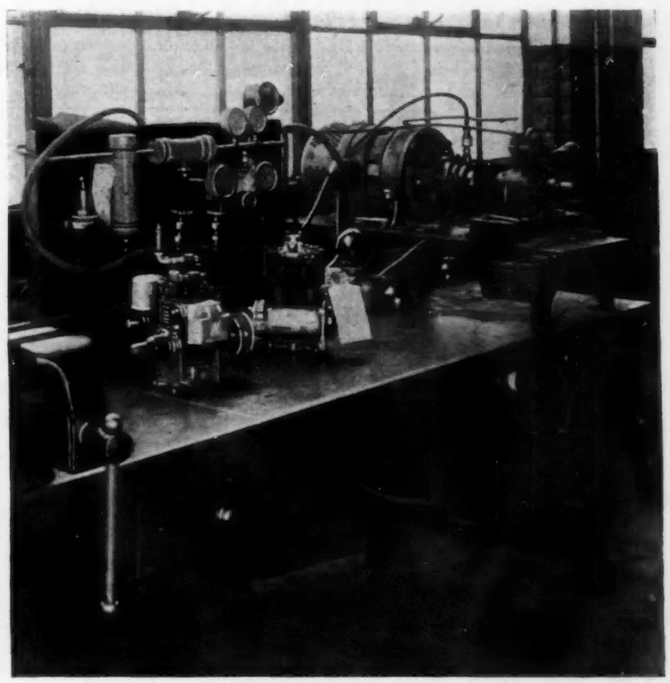


Fig. 14—Air-Brake and Compressor Section of the Machine-Shop

An Important Feature Is That the Efficiency of an Entire Unit Can Be Determined Before It Is Dismantled

FIG. 15—REPAIR PIT WHICH WILL ACCOMMODATE THREE MOTORCOACHES SIMULTANEOUSLY

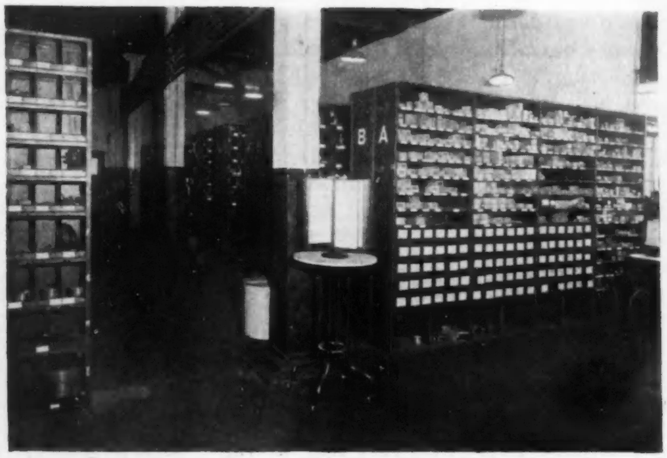


FIG. 16—STOCKROOM IN WHICH THE LOCATION OF EACH PART IS CATALOGED BY DESIGNATION LETTERS

and the returned goods memorandum number is placed on the tag for future information and follow-up.

Mileage figures are compiled by our transportation department and are not taken from odometers or recording instruments. Gasoline and oil-consumption records are kept according to coach numbers on a work sheet, Fig. 10. This bears the numbers of all vehicles in our service; spaces are provided for meter readings for both the start and the finish, and the difference in these readings gives the total quantity disbursed, which must check with the sum of the individual disbursements. Space is also provided for receipts, so that a daily inventory is taken of gasoline and oil. The mileage figures, together with the individual gasoline and oil disbursements, are entered on a daily record-sheet, Fig. 11. One of these sheets is provided for each coach and has spaces enough for one month's entries. A summary is made at the end of the month, as indicated at the bottom of the form, which includes gallons of gasoline and quarts of cylinder oil consumed on each route

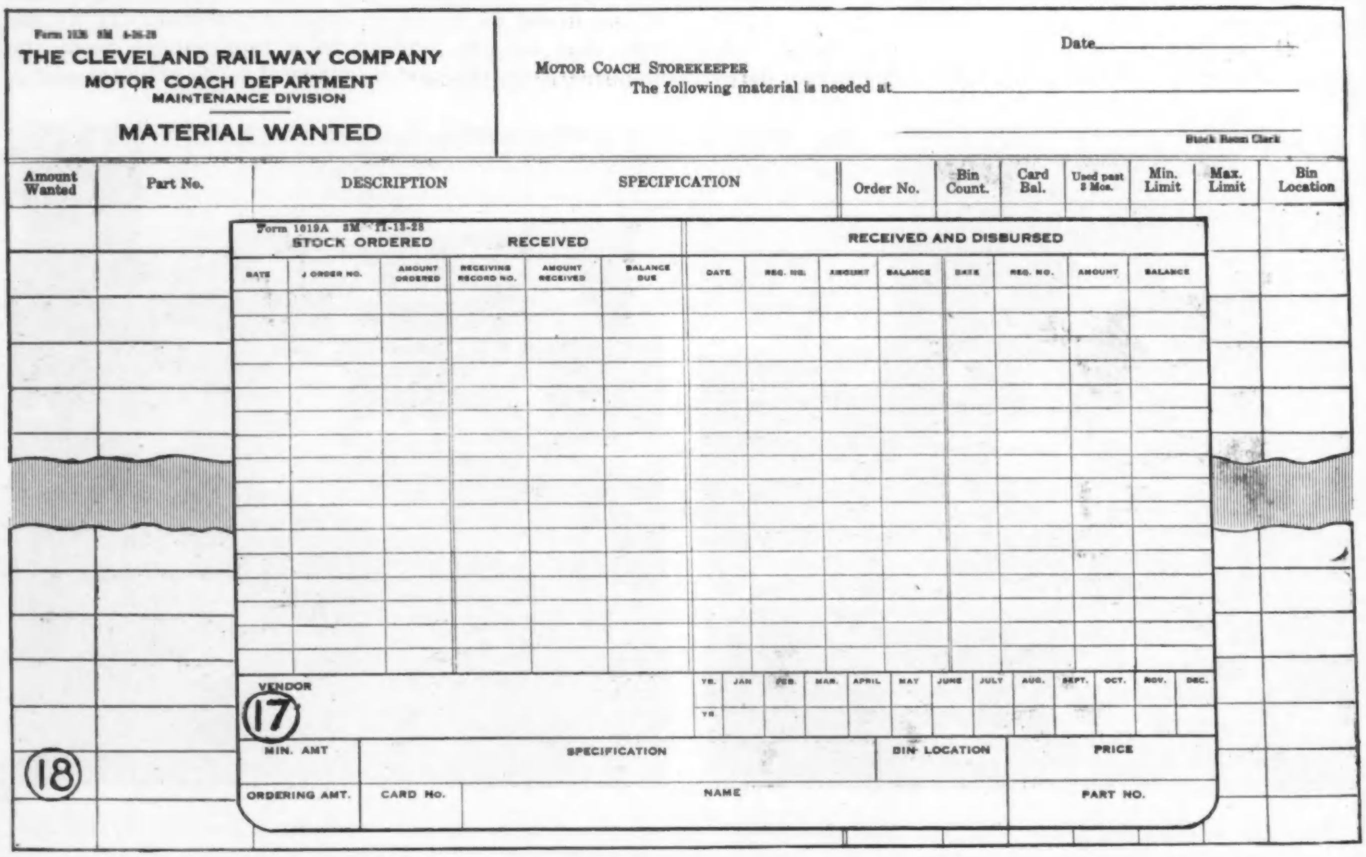


FIG. 17—REFERENCE CARD OF THE PERPETUAL-INVENTORY TYPE USED FOR KEEPING A RECORD OF PARTS

FIG. 18—SHEET USED FOR ORDERING, WHICH COVERS ALL ITEMS "FLAGGED" ON THE STOCK RECORD-CARD

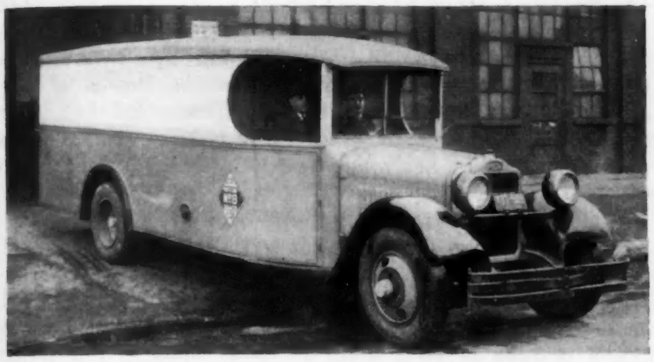


Fig. 19—Utility Truck for Stock Delivery

and the average miles per gallon of gasoline and per quart of cylinder oil. These sheets then become work sheets for the statistical department.

Overhaul-Garage Equipment and Methods

Our present overhaul garage, which is about equally distant from our operating garages, is approximately 100 ft. wide by 270 ft. long and, on our present maintenance schedule, provides ample space for both motorcoaches and motor-trucks. The personnel includes my assistant, who is actually maintenance superintendent, a general foreman or master mechanic, one body-repair "straw-boss," a working paint-foreman, one inspector, one mechanical engineer and assistant, one storekeeper, one stock chaser and four clerks. The mechanical force totals 44 men, including body repairmen, machine hands and porters. Six portable benches are provided, each erected on pressed-steel bench-legs, and 2-in. maple planks make up the major portion of the top, which is covered with 1/8-in. boiler-plate bent so as to cover the entire front edge. The benches are equipped with sheet-metal drawers, 20 x 20 x 6 in., having a sliding tray for small tools. The locker room has a steel locker for each man, and shower baths are provided.

We have attempted to eliminate guesswork and, wherever possible, equipment is provided and a standard test devised for determining the condition of units both before and after repairs are made. The machine-shop is shown in Fig. 12, the major units of its equipment being listed in Table 1.

Minor overhauls or 3D inspections consist of such unit replacements as air-compressors, carbureters, starter motors, generators, magnetos, engine-bearing take-up, new piston-rings; such work as carbon removal and valve overhaul, a general tightening of the chassis, a thorough cleaning, a paint touch-up, and such repairs as may be necessary to assure satisfactory operation for another 35,000 miles. This class of repairs was for-

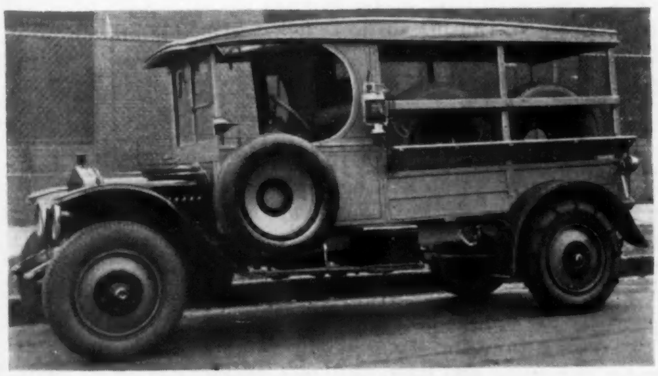


Fig. 21—Maintenance Truck Used for Response to Road-Service Calls

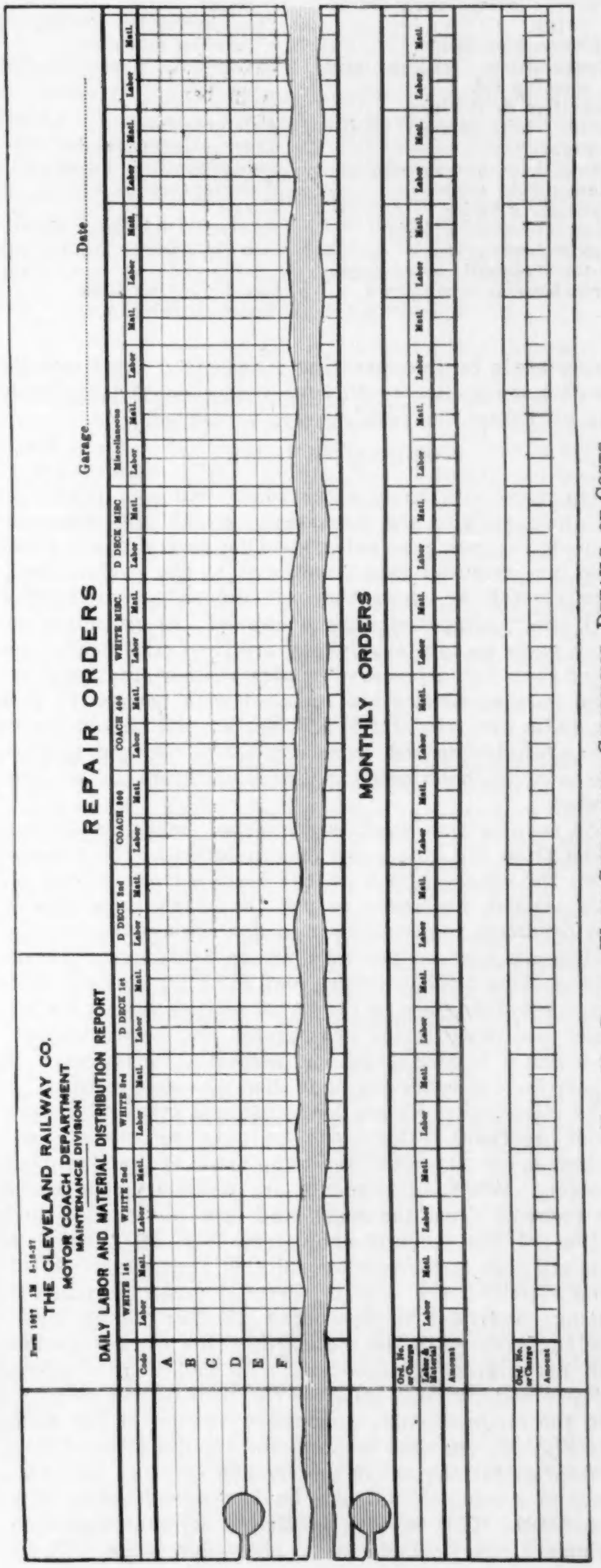


Fig. 20—Daily Work-Sheet for Compiling Details of Costs

TABLE 1.—MAJOR UNITS OF MACHINE-SHOP EQUIPMENT

Electrical test-bench, see Fig. 13	Connecting-rod-bearing fixture
Air-compressor test-bench, see Fig. 14	Sheet-metal squaring shear
100-hp. dynamometer	36-in. band-saw
Turret lathe, with 16-in. swing	Unishear cutter for sheet metal
21-in. engine lathe	Sheet-metal box break and forming machine
Brake-lining drilling and riveting set	Heavy-duty power sewing-machine
Sensitive drill-press	Engine stands
25-in. back-geared drill-press	Axle stands
Small floor-type grinder	Transmission stands
Heavy-duty grinder	Spray-painting outfit
Cylinder grinder	Welding torches
16-in. universal grinder	Forge
Brake-drum grinder	Hydraulic jacks, electric drills, sander, and small tools
60-ton hydraulic arbor-press	Parts-cleaning tank
Main-bearing boring-tool	Steam-cleaning outfit

merly made by the operating garage, but there was too great a temptation to fill runs with coaches taken from the pit before the repairs were completed.

THE MAJOR OVERHAUL

On major overhauls after 70,000 miles of operation all units, such as the powerplant, clutch and transmission, drive lines, rear axles, steering assembly and front axle, are removed intact and sent to the various unit-repair sections, where they are completely dismantled and their component parts cleaned for examination. Such parts as can be salvaged are then sent to the machine-shop for necessary repairs. Those that are beyond further service are replaced with new parts, and the units are rebuilt for unit stock. All chassis parts are carefully checked, loose rivets are removed and replaced with hot-riveted rivets, and brackets are rebushed.

As soon as this work is completed, rebuilt units are taken from the unit stock and installed in the chassis. Then the coach is sent to the body section, where all body repairs necessary to put the coach in as nearly new condition as possible are made. This work includes putting in new body-panels where necessary, and repairing floors, upholstering, roof covering, and the like. The coach then goes to the paint section, where the interior and the exterior are painted and varnished; after which it is road tested and inspected for defects. If in satisfactory condition, it is then placed in service.

All electrical units are inspected and repaired during major overhaul. Regulator and generator-brush adjustments are not permitted to be made at the operating garages. When adjustments are necessary, the units are removed from the coach and sent to the electrical section of the machine-shop (see Fig. 13), where a standard test is made with suitable apparatus. After being repaired, the unit is operated under normal operating conditions to determine whether its performance conforms with the standard. This work, together with carbureter, vacuum-tank and fuel-pump repairs, and also body wiring, requires the time of two men.

In the air-brake and compressor section of the shop (see Fig. 14) one man inspects and repairs all air-brake accessories for the entire motorcoach system. The efficiency of a complete unit can be determined before it is dismantled. This is very important with air-operated equipment, particularly with air-compressors. These are tested at various speeds under pressure to ascertain the output, which is determined by the pressure maintained while bleeding the reservoir through a fixed orifice. If these pressures are within the limits of our standard, the compressor is not dismantled but only minor adjustments to connecting-rods, cylinder-head nuts and the like, are made and it is then put back into service.

Included in the machine-shop force are two machinists, one man who specializes on grinding, and one bench worker. This department of the shop is largely employed in salvaging parts. The specialist grinds all brake-drums, cylinders, crankshafts and pistons. The bench worker is kept busy relining brakes, repairing fan-belts and doing miscellaneous bench work. The work in the engine-repair section keeps three men busy at all times dismantling and rebuilding engines and clutches. In another section, transmissions, steering-gears, front axles, drive lines, differentials and rear axles are rebuilt.

DYNAMOMETER TESTS OF ENGINES

Each rebuilt engine is tested on a dynamometer, the standard procedure being to jack-in the engine at 1000 r.p.m. by operating the dynamometer as a motor until the friction loss is within our standard for the type of engine. This usually takes from 4 to 6 hr. The spark-plugs are then installed and the engine is run under its own power with no load for $\frac{1}{2}$ hr.; then, at approximately one-quarter, one-half, three-quarters and full load, each run being of $\frac{1}{2}$-hr. duration. A horsepower curve is then charted, diagnosed and filed for reference. If the engine output is up to the standard for the particular engine-type and no unusual noises have developed, all nuts and connections are tightened, passed upon by an inspector, and the engine is placed in unit stock. This procedure makes it possible to discover defects that would cause very expensive failures in actual service.

The repair pit, shown in Fig. 15, is 40 in. wide and 96 ft. long and will accommodate three coaches at one time. The pit covers are made of subway-grating sections 12 in. wide fastened to the angle iron at the top edge of the pit by means of a toggle hinge, which enables one end of the grating to be dropped down into the pit. When the pit is open, the cover hangs in the pit flat against the side wall, thus solving the problem of pit-cover storage while the pit is in use. Three work-bays are adjacent to the pit proper, each connected with it by a passageway. In each of these bays is a work-bench equipped with a vise so that the mechanic does not need to leave the pit to do bench work. The pit is well lighted by lamps set in recesses in the walls, and is also piped for compressed air.

STOCKING OF REPAIR PARTS

Large quantities of repair parts are necessary for the successful operation of the maintenance department of a large fleet. Failure to have repair parts on hand when needed becomes very costly because of time lost by the mechanic, as well as increased time out of service chargeable to the vehicle. A well-balanced supply of parts is an essential labor-saving tool of maintenance.

Notwithstanding its importance, I believe the stock-room generally has been the least considered of all maintenance units. In our stockroom, shown in Fig. 16, the location of each part is cataloged by designating

letters in a visible-record file. Approximately $50,000 worth of repair parts are kept on hand, this inventory permitting a two-time turnover per year. The parts record-system is of the perpetual-inventory type. The record card, shown in Fig. 17, provides on the left side for balancing materials received against open orders. Material received is added to the balance shown on the disbursement side. The bottom of the card provides for information such as source of supply, specifications, bin location, last price paid, part name and number and, most important, the maximum and the minimum quantities to be carried in stock. These quantities are based on actual past consumption and the average lapse of time between requisition and receipt of the material in question, the minimum quantities representing the consumption during this period. Three times the minimum quantity represents the maximum quantity. These limits are constantly being revised at the time of ordering. Disbursement entries are made and the balance on hand is carried forward daily. The parts requisition is priced for costing purposes at the same time, and the balance on hand is checked with the minimum limit. If the balance is below the minimum, the stock card is "flagged" by placgin a blue card over it. Stock-record cards are made accessible by use in conjunction with a visible file.

Late in the day the clerk makes out a material-wanted sheet, Fig. 18, which covers all items flagged on the stock-record card. He transfers to the sheet the part number, part name, specification, balance shown, and the quantity used during the last three months. From this last information new minimum limits for this stock are computed. If the stock used in three months is greater than the amount on hand, an order is placed for the maximum quantity. The sheet is then passed to the stockroom, where the items in the bin are counted and recorded on it. This gives the record clerk information with which to correct his cards. An additional check to prevent parts shortages is provided by use of a blue stock-shortage tag on which the date, part number, part name, bin location and bin count are recorded. Should the person disbursing stock from the bins find that the stock has been depleted below a safe minimum, he hands this blue tag to the storekeeper for his investigation and disposal.

Our operating-garage stockrooms are set up on the same basis as that for the shop; but the maximum quantity to be carried is one month's consumption and the minimum quantity, at which to order, is one week's consumption. This, in our experience, is an ample margin, and the movement of stock, tires, and the like can be handled by one truck and its driver. This truck, shown in Fig. 19, operates on a regular daily schedule. We insist that our operating garages anticipate their needs so that extra trips of the truck will be unnecessary, these being permissible only in cases of emergency.

Our maintenance accounting and statistical work is handled by four clerks, the costs being kept by fleets, whereby comparisons can be made between the various makes of coach. The totals are broken up into costs of the various units such as the engine, transmission, clutch, propeller-shaft, and differential. To simplify compilation, a daily work-sheet, Fig. 20, is provided. Code letters from A to T are used for recording the daily itemized labor and material consumption. These are used as posting media to ledger accounts.

Miscellaneous Equipment

An operation such as ours requires a number of maintenance trucks for road service. Four ¾-ton trucks are in service (see Fig. 21), one at each of the three garages, for responding to minor road-service calls, and one for utility purposes, mostly for spreading salt and sand during icy weather. Two 2½-ton trucks, each equipped with a winch, are used for spreading salt and sand at coach stops when the pavement is icy. In addition, three spreaders for salt and sand are provided, these being towed by the 2½-ton trucks. Gasoline-storage facilities for 30,000 gal. are provided at one operating garage. Gasoline is delivered here in tank-car lots, and our 1000-gal. tank-wagon distributes it to the other two garages.

Summary

I have attempted to set forth the fundamentals that have been followed in building and bringing to its present standard a maintenance organization that is operating 175 pieces of equipment, including motorcoaches and motor-trucks. Including my assistant and myself, there are 126 men in this department. The coaches are now operating 380,000 miles per month, or at the rate of 4,500,000 miles per year. Approximately 97,000 gal. of gasoline is consumed per month. That the ideas have been at least moderately successful when put into execution is evidenced by the operation itself and by the fact that the standard of the operation is constantly being raised while the cost per unit has been constantly lowered. Therefore, I am convinced that these fundamentals can be applied with equal success to maintenance of other types of vehicle.

THE DISCUSSION

P. V. C. See[2]:—We have found that foremen's meetings are very valuable. We use charts to show each foreman what he has accomplished in regard to reducing costs, the number of pull-ins and road calls, and various other items of interest. We also find it valuable to post the amount of gasoline used by each vehicle so that the mechanics can make comparisons. For the last several years we have tested every engine on the dynamometer, and rebuilt engines are giving an average of 40,000 miles of service.

Leonard Rose:—We do not post a record of average gasoline-consumption, but the foreman is provided with a chart showing the average gasoline-consumption of the motorcoaches in service.

H. J. Beemis[3]:—What small tools are the mechanics required to own, and what special tools does the company furnish?

Mr. Rose:—The mechanic must own a complete set of wrenches, and tools such as a hammer, pliers and

[2] M.S.A.E.—Superintendent of equipment, Northern Ohio Power & Light Co., Akron, Ohio.

[3] Equipment engineer, The Milwaukee Electric Railway & Light Co., Milwaukee.

screwdrivers. We provide special wrenches and other tools such as drills, reamers and micrometer calipers; the more costly tools are loaned to the mechanics and checked against the mechanic who uses them until they are returned.

A. J. SCAIFE[4]:—What percentage of the total operating cost is represented, respectively, by oil, gasoline, mechanical repairs and labor?

At a recent meeting of the American Petroleum Institute it was brought out that about 30 per cent of the total operating cost is constituted of these four items. Why is it not possible to reduce the overhead cost, which represents from 70 to 80 per cent of the total operating cost? Some operating costs are as low as 20 per cent.

MORSE W. REW[5]:—Our operating cost averages approximately 40 per cent of the total cost. Mr. Scaife calls all the rest overhead expenses. The overhead expense of our department is about 17 per cent, not 70 per cent, and the balance is charged as transportation cost. The reduction of transportation cost is very difficult and depends upon many factors such as the length of the routes, the headways, and the necessary lay-overs. In the case of the Cleveland transportation system, we have one main motorcoach route and the other routes are scattered. It is about 26 miles between the northerly and the westerly corners of the territory served, and therefore the needed inspections are more costly than in the system maintained by Mr. See, where most of the lines run downtown.

MR. SCAIFE:—Mr. Rew answered my question when he stated that 40 per cent is the operating cost. I realize that there are certain requirements, caused by conditions over which one has no control, that must be taken care of and they add to the costs.

MR. REW:—With regard to maintenance and operating expenses, I believe that the cost of gasoline and oil is specified as a power charge in the rating by the Interstate Commerce Commission; it is not a maintenance charge. In quoting the figure of 40 per cent for operating cost, I included that item.

THOROUGH DIAGNOSING NECESSARY

MR. BEEMIS:—Is not much time wasted because a thorough diagnosis of the needs of the vehicle is not made at the time of inspection? The road test has some value but, in making such a test, the vehicle is operating under conditions more or less abnormal and such a test is hazardous. For example, the vehicle is operating on streets not assigned as motorcoach routes and where their presence is unexpected. I think that more can be done in the garage in determining operating conditions. We have recently used a device for determining the percentage of leakage past the pistons and the valves of the engine. It is in effect a bypass valve for use in connection with the compressed-air system in the garage. Compressed air is injected into the combustion-chamber and allowed to leak out through a calibrated orifice. The percentage of leakage is read directly on a gage. I believe that the use of this device is a step in the right direction.

Further, a considerable amount of valuable information can be obtained from a study of the drivers' daily defect-cards that are turned in between the inspection periods. This information, together with the history of the vehicle as determined from preceding inspections and as thorough a test on the floor of the garage as can be given, makes it unnecessary to conduct a road test preceding an inspection; consequently, we have recently abandoned road testing.

MR. ROSE:—Some conditions that do not manifest themselves and are not reported on the drivers' defect-cards do cause failures that cannot be discovered except by making road tests. A part that has never failed and is on the point of failing can become a very expensive item. I believe that the public can be educated to become accustomed to the road testing of motorcoaches. It is a hazardous procedure, but I believe it is a risk that we must take.

QUESTION:—What means have you of compiling data on the percentage of maintenance that is devoted to care of bodies?

MR. ROSE:—Chassis repairs and body repairs are the two major classes of our costs. These are separated into their component parts; for example, the cost of glass, painting, body panels and the like.

CHAIRMAN FERDINAND JEHLE[6]:—Why do you consider a turret lathe necessary in your machine-shop?

MR. ROSE:—Sometimes we must manufacture parts because of not having a certain part in stock or because the manufacturer has gone out of business. We can do any work on the turret lathe that we can do on the engine lathe and, in addition, such manufacturing as we require.

MR. SEE:—For our street-car work, we have several lathes of various sizes, but we use a turret lathe for work on motor-vehicles.

LONGER INSPECTION INTERVALS

MR. ROSE:—At first we believed it necessary to drop the crankcase and make an inspection after each vehicle had run 15,000 miles, but we increased the inspection interval successively to 20,000, 25,000, 30,000 and 35,-000 miles, which last figure is the present interval. Data obtained from road-testing the vehicle have enabled us to increase the interval from 15,000 to 35,000 miles.

MR. BEEMIS:—Fouled spark-plugs which are not otherwise defective are sometimes removed and the mechanics are reluctant to use second-hand plugs even though they have no reason for suspecting that the plugs are not good. We use a testing device which tests the spark-plug under pressure. Spark-plugs that are removed are first examined for defects for which the manufacturers of the plug sometimes make replacement. The remaining plugs are then assorted to remove those that are damaged beyond repair. Those remaining are again assorted and plugs that need cleaning are boiled in trisodium-phosphate solution to remove the carbon, although this method does not remove the carbon entirely. Afterward, the spark-plug points are adjusted to provide a gap of 0.025 in. The plugs are then tested with the device already mentioned. If they pass that test, they are returned to service but are not charged to the vehicle in which they are installed.

MR. ROSE:—Our practice is the same except that our weekly inspection includes the removing of spark-plugs and readjusting of the points. All such inspection work is done by one man in the garage, and it is comparatively simple to train that man to diagnose troubles.

[4] M.S.A.E.—Consulting field engineer, White Motor Co., Cleveland.

[5] Superintendent, motorcoach division, The Cleveland Railway Co., Cleveland.

[6] M.S.A.E.—Research engineer, White Motor Co., Cleveland.

Material Handling in the Pontiac Assembly Plant

By N. H. PREBLE[1]

PRODUCTION MEETING PAPER — *Illustrated with* PHOTOGRAPHS AND DRAWINGS

CONVEYORS and handling systems often are planned and installed after a building is erected. The Pontiac plant, described in this paper, is an exception because it was designed without limitations as to space and for a definite production program.

With the aid of photographs and floor plans on which the positions from which the photographs were taken are indicated, the complete production line of the plant is shown in detail. The order of assembly and the points at which various units are applied to the chassis are shown; also the locations of the storage spaces for many of the parts and the provisions for transporting them to the assembly line.

Among the striking features of the chassis-assembly line is a hump, midway of the length of the building, which raises the chassis to the mezzanine level to allow passage underneath. Features of the handling system are the simple gravity-conveyors that carry the storage batteries under the floor and up beside the assembly line, a chain conveyor for transferring completed cars to the storage building, and gravity-roll conveyors on which export boxing is done.

Discussion of the paper centers on the problem of scheduling wheels, fenders and other parts of various colors and forms to meet corresponding bodies in the assembly line.

ONE of the newer plants in the automobile industry is the new Pontiac assembly plant of the Oakland Motor Car Co., which was designed and erected under somewhat unusual conditions. It is located on the outskirts of the city of Pontiac on land which, at the time the building was erected, had not been subdivided. With no adjacent buildings, there were no limitations as to the space that could be used. Ample railroad facilities were available, and the Fisher Body Co. unit, which manufactures bodies for the Pontiac car, is located on the other side of the main railroad line. This plant was built complete from the ground up; the type of car to be assembled had been established, and the volume of production was known.

The buildings completed at the time of writing this paper include an engine plant and separate storage buildings for the Pontiac and Oakland divisions. This paper will describe the Pontiac assembly plant; the Oakland plant is laid out along very similar lines. The engine plant will not be included. A foundry for gray-iron castings is now under way, and land is available adjacent to the present buildings for further extension of the Pontiac plant.

A general view of the interior of the Oakland assembly plant is shown in Fig. 1, and plans of the two floors are shown in Fig. 2. Locations of many of the assembly and subassembly operations and storage spaces are indicated in the plans by lettering; and numerals with arrows indicate where each of the photographs used in this paper was taken and the direction in which the camera was pointed. Feeding lines and points where many of the units are dropped or fed to the main assembly line also are shown.

Under roofs on each side of the assembly building are located railroad tracks where incoming shipments are received. The main assembly building of the Pontiac plant is 180 ft. wide by 1260 ft. long, of steel construction, with a central bay and second-story mezzanine balcony on each side. A portion of the area has a basement, and on one side of the central bay there is a third story which contains enamel-oven equipment. The photograph reproduced in Fig. 1 was taken from the mezzanine, looking down the central bay toward the beginning of the chassis-assembly line. A third line has now been installed between the

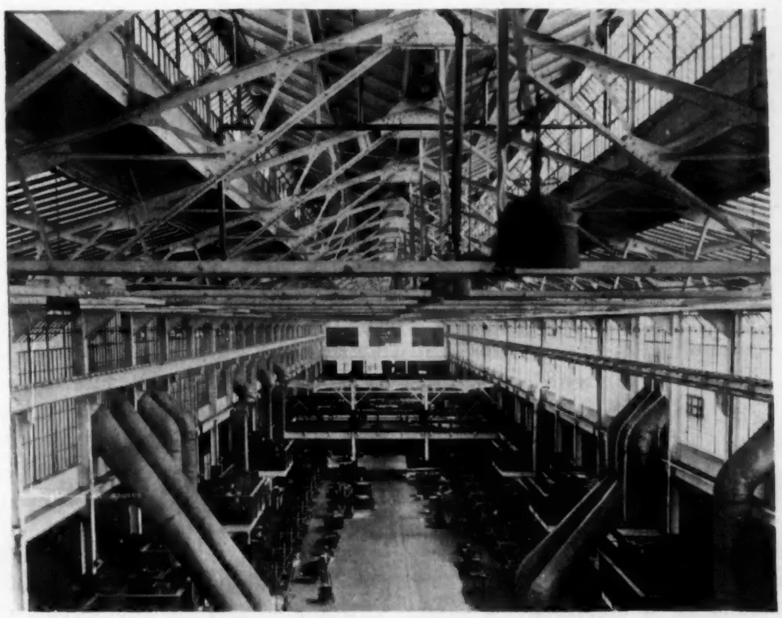


FIG. 1—GENERAL VIEW OF THE PONTIAC ASSEMBLY PLANT

[1] Vice-president in charge of engineering, Mechanical Handling Systems, Inc., Detroit.

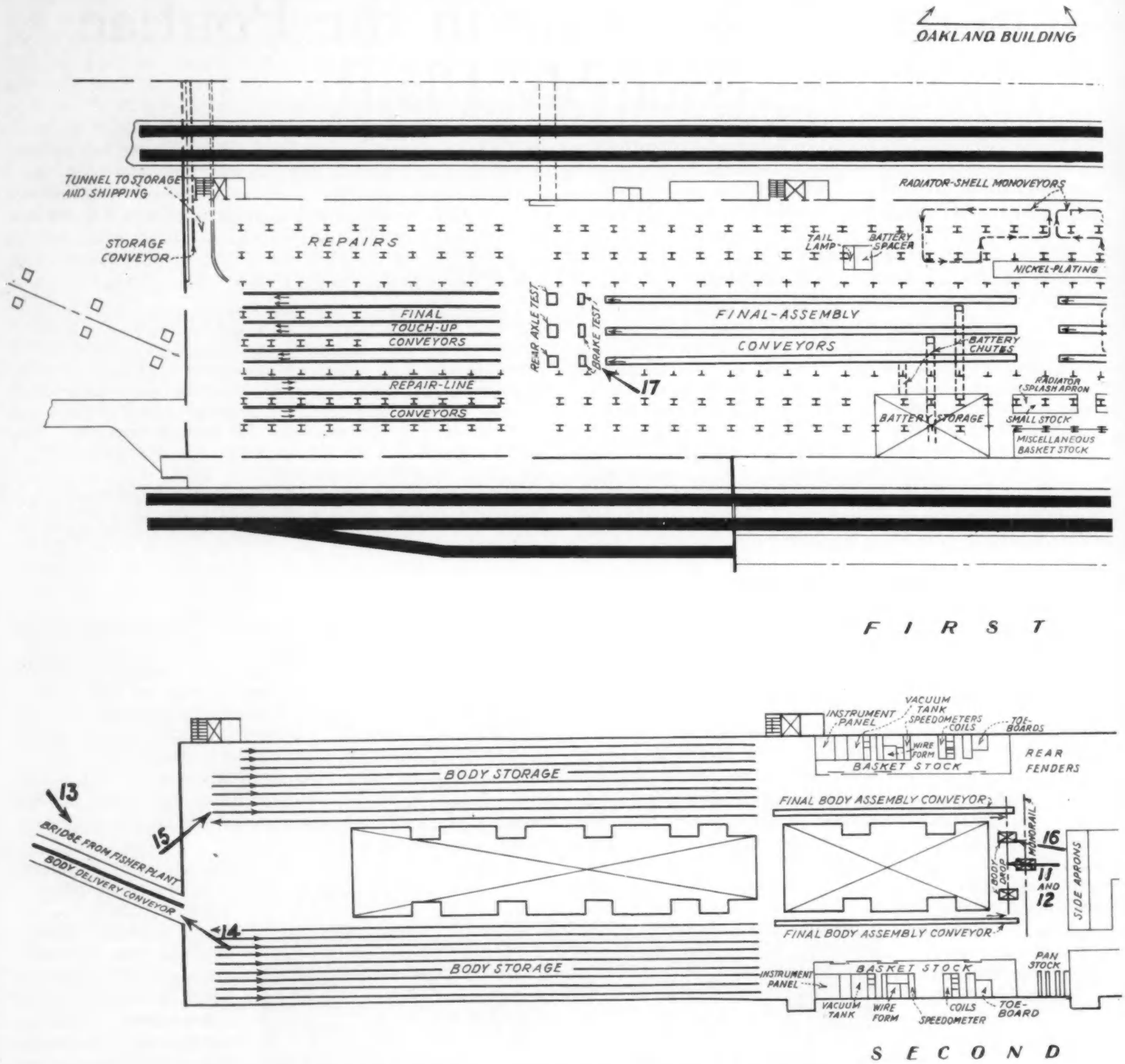


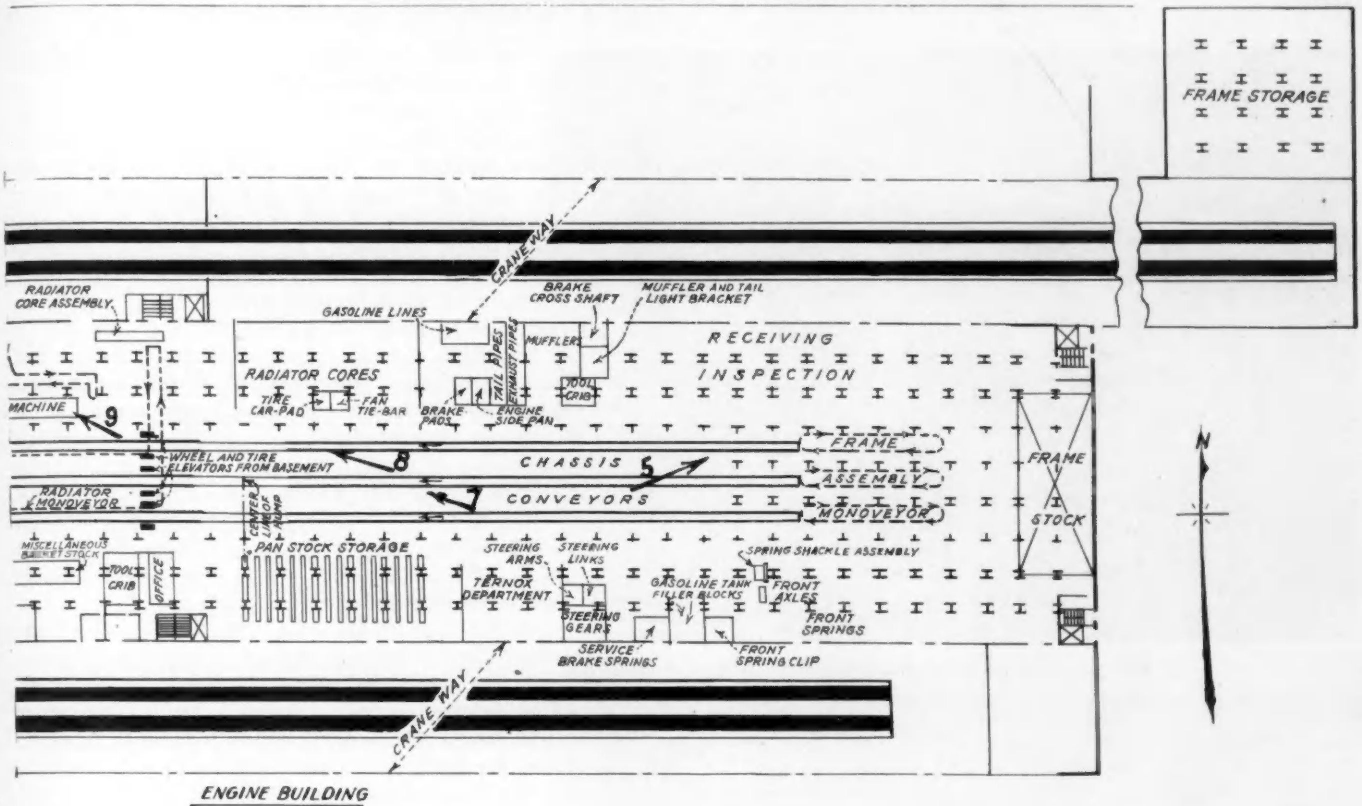
FIG. 2—FLOOR PLANS OF THE PONTIAC PLANT OF THE OAKLAND MOTOR CAR CO.

Above Is the Plan of the First Floor, and the Second Floor Is Shown Below. Figures with Arrows Indicate the Location and Direction of the Camera in Taking the Correspondingly Numbered Photographs Reproduced with This Paper. Many of the Storage Spaces and Assembly Operations Are Indicated by Lettering on the Plans. North Is Directly Upward on the Page. Bodies Come from the Fisher Plant Through a Bridge at the West, and Frames Come from a Storage Building at the Northeast. The Engine Building Is Just South of the Building Shown, and the Oakland Assembly Plant Is Immediately North, Separated Only by Craneways over the Enclosed Railroad Tracks Shown by Heavy Black Lines

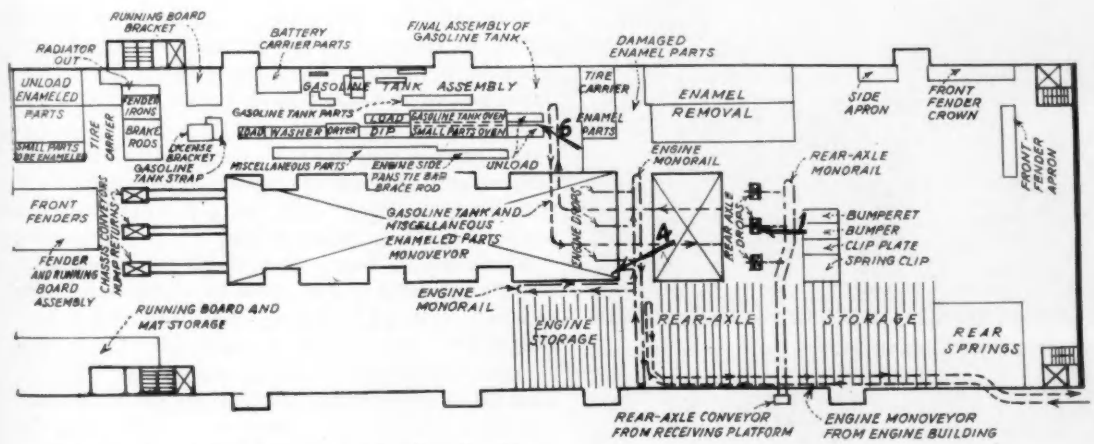
two shown, pits having been provided when the building was erected. The photograph serves to indicate the general construction of the building.

BEGINNING THE ASSEMBLY

Frames are assembled complete, with the exception of the running-board brackets, when received from the manufacturer, and are stored in a separate building. They are handled in the same general way as at the plant of A. O. Smith Co., being stored on special racks and handled in batches of five or more by a specially constructed crane-sling which transports them to a point near the beginning of the assembly line. There they are hung on an overhead monorail which carries them through the riveting machines for riveting on the running-board brackets and battery box. They are then transferred to a slide immediately adjacent to the beginning of the chassis-assembly line, and while on this slide the front axle and front springs are installed, the frames being upside down. After installation of the



F L O O R P L A N



F L O O R P L A N

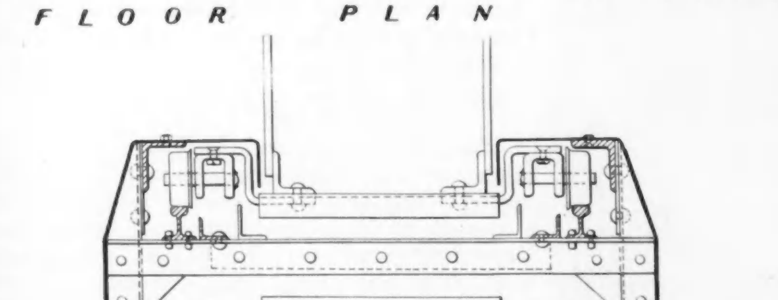


Fig. 3—Section of the Conveyor Used for the Main Assembly Line

This Conveyor Consists of Two Strands of Chain on Which Are Mounted Carriages To Support the Frame. The Upper Strands of the Conveyor Chain Are Well Protected, and a Continuous Pan Prevents Articles from Falling upon the Return Run

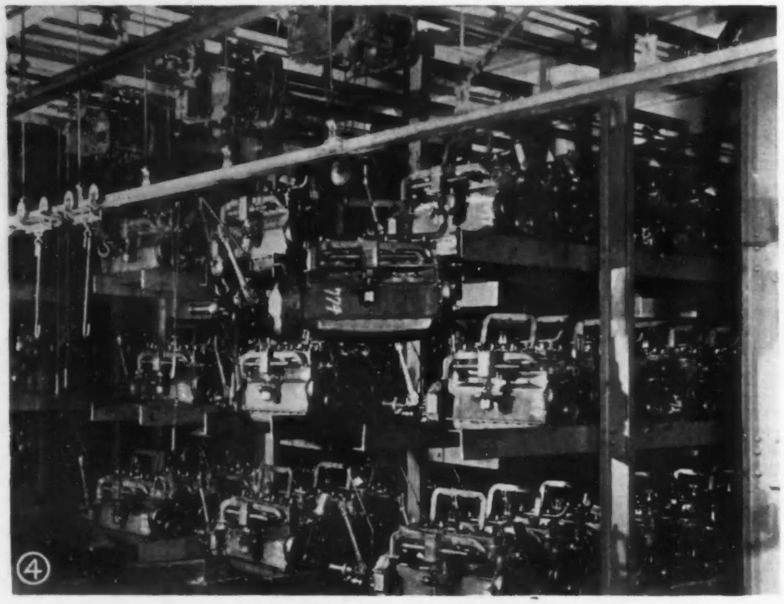


FIG. 4—ENGINE STORAGE RACKS

FIG. 5—DROPPING THE ENGINE INTO PLACE

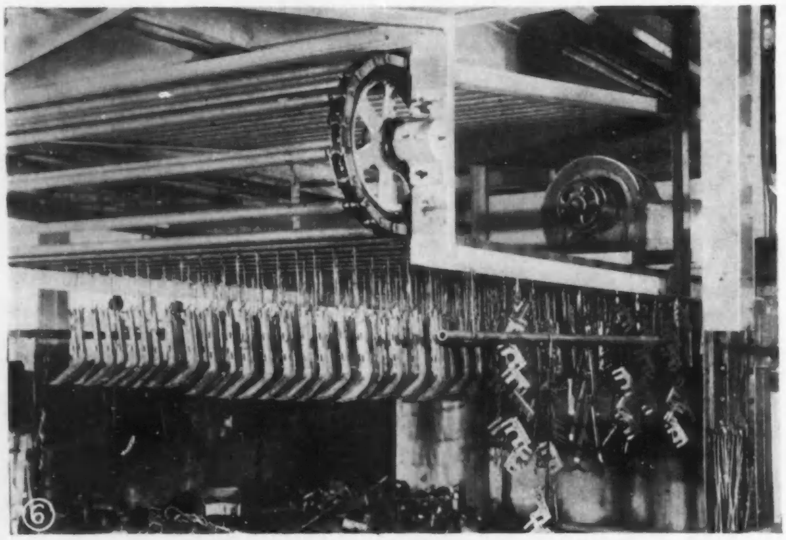


FIG. 6—LOADING END OF ENAMELING CONVEYOR

front axle, the frame is slid on to the carriers of the chassis-assembly conveyor.

This conveyor is shown in cross section in Fig. 3. The general construction comprises two strands of chain carrying at proper intervals carriages for the front and center cross-members of the frame, when in the upside down position, and for the front and rear axles, when the frame is right side up. The details of construction are so arranged as to provide a guard over the chain to protect it from paint spray when passing through the spray booths. The larger light angles toward the center, shown without cross-hatching in Fig. 3, are provided only in the spray-booth section. A continuous pan extends under the upper run of the conveyor chain to catch any bolts, nuts or other articles which are dropped, preventing them from falling into the return run. The sides also are guarded with sheet-metal enclosures.

After the frame has been put on the conveyor, the rear axle, gasoline tank and brake-rods are assembled while the frame is inverted. The frame is then reversed by means of a turn-over fixture mounted on a monorail track, and is ready for installation of the engine. Powerplants are conveyed by an overhead trolley conveyor to the balcony from the block test, located in the engine plant, which is just south of the assembly plant. In the balcony they are stored in racks, as shown in Fig. 4. From the storage racks they are conveyed again by means of a monorail track to the engine drop, where they are lowered on to the frames as the chassis pass below, as shown in Fig. 5.

On the second-floor balcony is located the small-parts enamel-oven, the loading end of which is shown in Fig. 6. In this oven are enamelled the gasoline tanks, spare-tire racks, running-board brackets and other miscellaneous small parts. The gasoline tanks and tire carriers are distributed from the unloading end of the oven to the assembly line by means of the overhead conveyor shown in Fig. 7. This photograph also shows further details of the chassis-assembly conveyor itself and, in the upper background, the overhead track carrying the powerplants from the storage racks to the engine drop.

HUMP ALLOWS PASSAGE UNDER THE LINE

After the engine and other smaller items are mounted, the chassis passes through the spray booths and then goes up an incline to a balcony at the second-floor level, where the front fenders and running-boards are assembled. The last of the spray booths and the incline are seen in Fig. 8. One purpose of this hump is to obviate the necessity of bringing the bulky fenders and running-boards down to the first floor, but the provision of a passage for transportation through the line is of even greater importance. The total length of the assembly line, including the final assembly and

touch-up lines, is approximately 1200 ft., with almost no opportunity for passing through. This hump occurs at about the center of the building and has been found of great advantage.

After the chassis comes down from the hump, the wheels—which have been brought up from the basement by means of conveyors adjacent to both sides of the assembly line—are mounted. The entire wheel department is located in the basement. Wheels and tires are received at one side of the building and distributed by means of chutes to the basement, where the wheels are painted and the rims and tires assembled. The wheels are carried on racks during the painting operations, and while passing through the drying ovens, on conveyors very similar to those used in the body plant. Distribution from storage to wheel assembly is taken care of by overhead conveyors.

The radiator-shell and assembly departments are located on the right-hand side of the assembly lines, and include the plating, polishing and buffing operations and the assembly of the core with the shell. Fig. 9 shows the loading end of the automatic continuous-plating equipment. The shells are hung on cross-rods that are carried automatically through the various wash and rinse tanks and into the plating baths by cam-operated arms which pick the carrying rods up from the conveyor chain and lift them from one tank into another, the complete operation being automatic. Fig. 9 also illustrates the overhead conveyors for carrying the shells through the washing machine and to and from the polishing and buffing wheels. After assembly of the shell and core, the radiators are placed in trays on an overhead conveyor for transportation to the assembly line. Mounting the radiators is the last operation before the chassis passes from the chassis-assembly line on its own wheels to the final assembly.

Pits Under Assembly Conveyor

The final-assembly conveyor is of double caterpillar-type construction, cross-sections being as indicated in Fig. 10. The caterpillars are flush with the floor, so that a car can be rolled off at any point; and there are no connections between the two chains, so that work pits can easily be provided for under-body work, as shown at the left in Fig. 10.

Fig. 11 is a view from the balcony, looking down upon the final assembly. This photograph also was taken before the third assembly line was installed, and the covered pit for this line can be clearly seen. The conveyors in the foreground of Fig. 11, for bringing batteries from the battery department at the left of the lines,

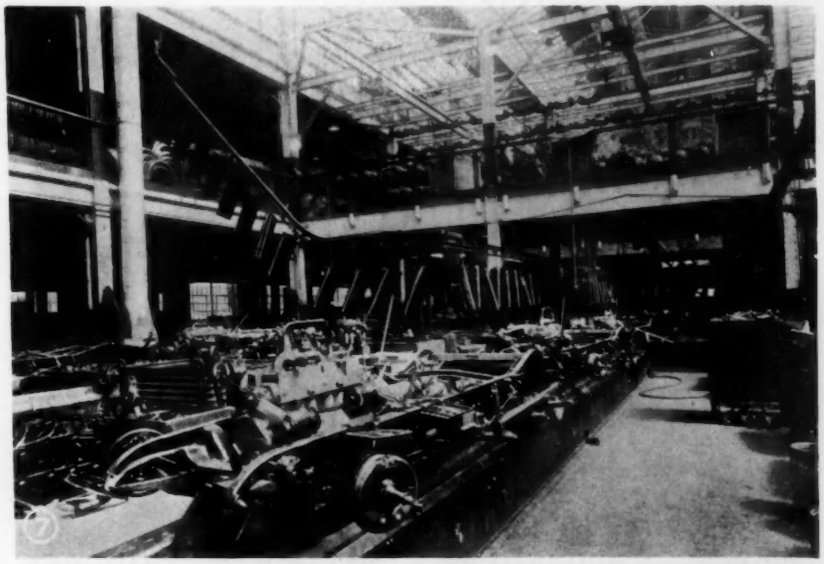


Fig. 7—Conveyor from Enameling Oven to Chassis Line

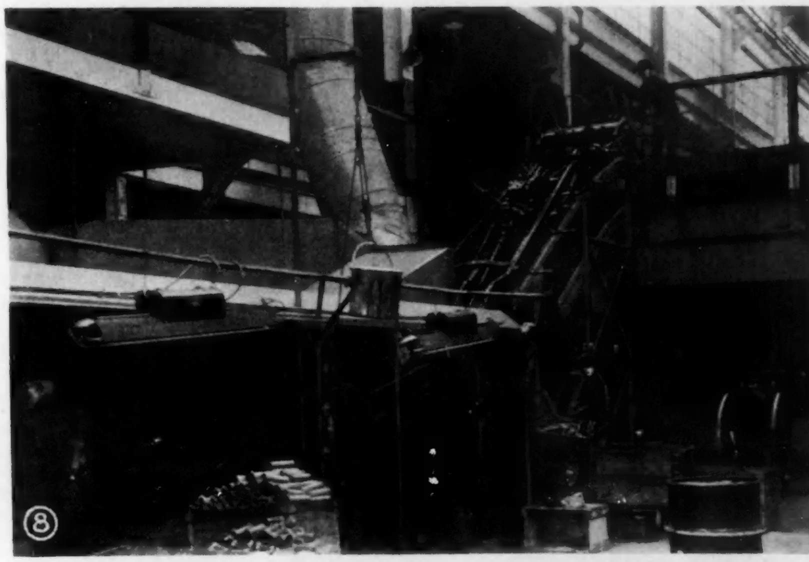


Fig. 8—Paint-Spraying Booth and Hump in Line

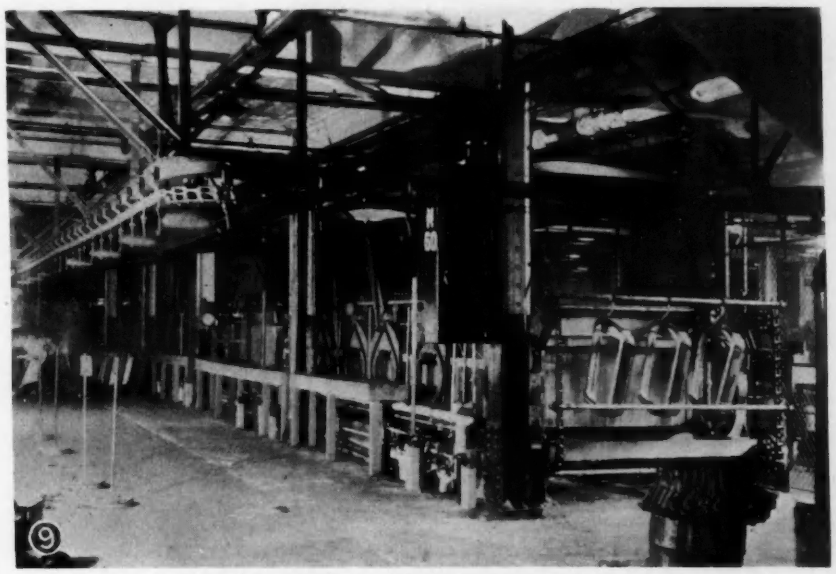


Fig. 9—Automatic Plating Equipment for Radiator Shells

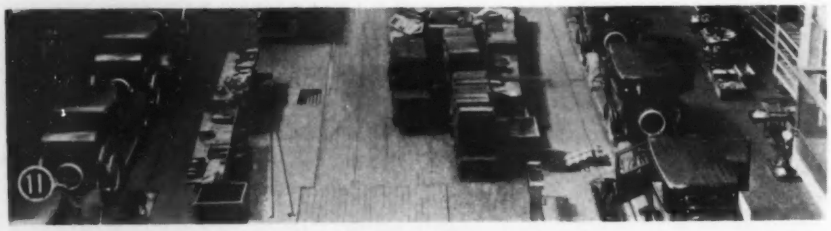


FIG. 11—FINAL-ASSEMBLY LINE

FIG. 12—BOLTING THE BODIES IN PLACE

FIG. 13—BRIDGE FROM FISHER BODY PLANT

FIG. 14—CONVEYOR THROUGH BODY-PLANT BRIDGE

consist of tunnels provided with gravity rolls. The slopes and elevations are so arranged that the weight of batteries at the loading end causes the replacement of that of batteries as they are removed at the unloading end, making a very simple, fool-proof and ingenious means of getting the batteries alongside the assembly lines. Fig. 12 is from a later photograph of the final-assembly line, and shows the work pits in the immediate foreground.

Immediately after the chassis is placed on the final-assembly conveyor, the body is lowered from above. As mentioned before, the Fisher body-plant which manufactures the Pontiac bodies is located across the railroad track, about 1/4 mile from the Pontiac assembly-building. A bridge has been constructed between the two plants and a double-strand conveyor installed to transport the bodies to the assembly plant. Fig. 13 is an exterior

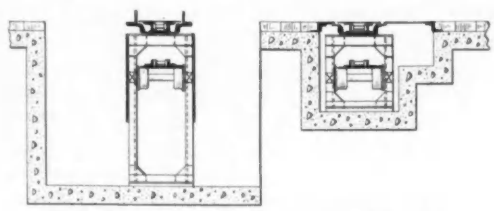


FIG. 10—FINAL-ASSEMBLY CONVEYOR

This Conveyor Consists of Two Caterpillar Tracks Flush with the Floor. The Space Between the Tracks Is Clear, Making It Available for Pits, as Shown at the Left

view of this bridge, taken from the body-plant end, with the lumber storage below and the assembly plant in the background. The main line of railroad tracks and the spur tracks into the Fisher and Pontiac plants can be seen in the center of the photograph. Fig. 14, from the Pontiac end of the bridge, shows the general construction of the conveyor, which is approximately 1400 ft. long on centers and is kept full almost all of the time. When filled, it carries about 150 bodies, and a 5-hp. motor is ample to carry the load.

APPLYING BODIES, TESTING AND TOUCHING UP

The bodies are taken off the conveyor, put on to the standard type of body-truck and stored on dolly track-lines, the bodies being conveyed down the line by an air-cylinder pusher device, as shown in Fig. 15. As the bodies are required, they are taken from the trucks on the storage line and placed sidewise on a final-assembly conveyor, of double-strand construction, seen in the background of Fig. 16. Here the rear fenders, vacuum tanks, speedometers and other dash accessories are installed. Bodies are removed by means of

an overhead monorail hoist, and transported to the body drop, as illustrated in Fig. 16.

After the installation of the lamps, floor-boards and such parts, the completed car is run off the final-assembly line on to a Cowdrey four-wheel brake-testing machine, seen in Fig. 17. for brake adjustment. Then the car is run-in, with the rear wheels resting on heavy rolls, and passes to a final touch-up line for touching up and inspection. There are two of these lines to each chassis line. They consist simply of a single strand of chain with a collapsible dog which engages with the rear-axle housing, the wheels at one side running in a channel track. Cars that are rejected for any reason are passed to either side under the balconies for repair, the repair facilities including an elevated testing-stand with large rolls for the rear wheels, for further running-in, and stalls for various jobs.

After the car has passed inspection, it is taken, by a conveyor similar to that of the touch-up line, through a tunnel under the receiving tracks into the storage building. From the end of this conveyor the cars are distributed to the storage building or to the export-boxing department. Cars to be shipped in box-cars have their frames bolted down to the axles to prevent spring action in transit, this job being done over a pit with the aid of an air-cylinder. Special hub-caps are used for tying the car down in the box-car. In the export-boxing department, which is in this same building, the cars are knocked down and boxed on gravity-roll conveyors, lines of which lead to a cross track equipped with an electrically driven transfer-car that is also fitted with gravity rolls so that the box can be rolled on to the car. This car takes the completed box down where it can be picked up by a crane for loading on flat-cars.

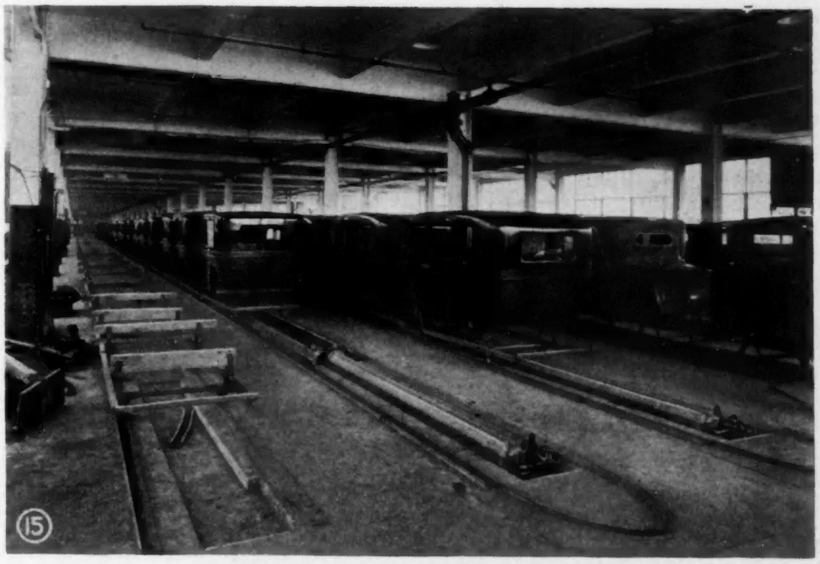


FIG. 15—BODY-STORAGE SECTION

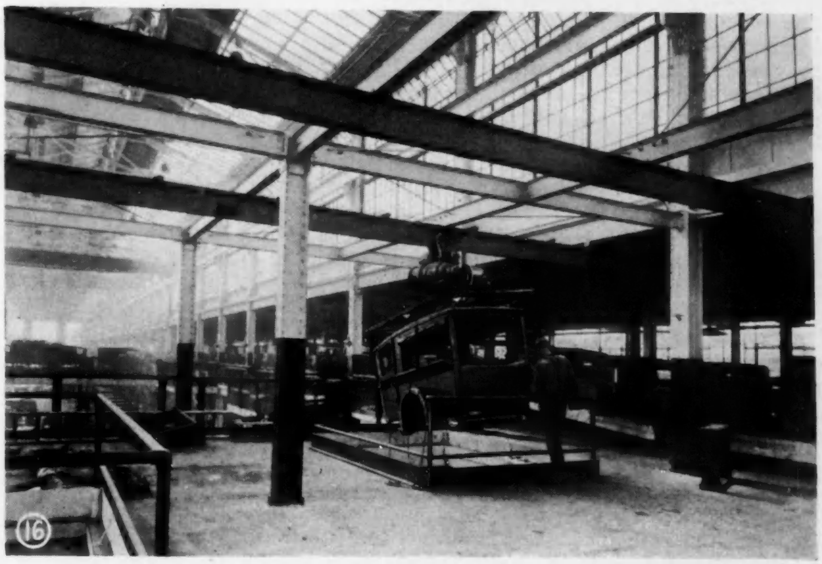


FIG. 16—DROPPING THE BODY ON TO THE CHASSIS

FIG. 17—TESTING THE FOUR-WHEEL BRAKES

THE DISCUSSION

L. A. CHURGAY[2]:—Assuming that two-door and four-door sedans, coupés, roadsters and other models of various colors are coming through the assembly lines, how are the wheels and other parts timed to meet the corresponding bodies on the conveyors?

N. H. PREBLE:—Bodies are segregated according to type and color at the storage tracks on the second floor. A schedule is worked out and passed to the wheel division, as well as to the car-assembly division. Occasionally, changes in color affect the fenders also. The orders get mixed up sometimes and wheels accumulate alongside the chassis line, but the dis-

[2] M.S.A.E.—Plant equipment engineer, Chrysler Corp., Detroit.

patching usually works out well, as it is planned at the beginning of the day. Undoubtedly Mr. Rumely can tell more about the problems of handling assorted colors.

CHAIRMAN V. P. RUMELY[3]:—Recent developments—with wheels of natural-wood finish and of many colors, wire wheels, demountable wheels, and fenders of various shades to harmonize with body colors—have imposed quite a problem on the assembly department. This is particularly acute at our assembly plant, because the body plant is located about three miles from the main factory, and any body is furnished in any one of five optional colors, with a grand total of 15 colors. After much study, we adopted a schedule system, operated from a central point from which the master schedule is dispatched by means of a telegraph system with recording instruments at some 14 receiving points. A schedule is laid out for the day, and this usually can be followed with few if any changes.

[3] M.S.A.E.—General stores manager, Hudson Motor Car Co., Detroit.

Air and Rail Traffic Comparisons

CLASS 1 railroads of the United States have lost between 25 and 30 per cent of their passenger traffic in eight years; in fact, they made less passenger-miles in 1927 than they did eleven years ago. Automobiles and buses have taken much of their short-haul traffic. By consolidations and cooperative effort, long-haul bus lines are now operating between New York and Los Angeles, and as soon as they become better organized, still further inroads will be made upon steam-railroad passenger traffic. Now the airplane has entered the field to compete for long-haul business.

It should be encouraging to the airplane industry to know that farsighted railroad officers are joining in the development of this service. Only by constructive assistance, cooperation and coordination on the part of the railroads, can the public quickly get the service it demands and is willing to pay for.

The proposed New York-Chicago airplane service will be compared with steam-train operation. The loads estimated are about three-fourths of respective capacities, namely, an extra-fare train with ten cars and 100 passengers and baggage, versus a 12-passenger airplane carrying nine passengers and baggage.

DISTANCES, FARES AND SCHEDULES

The distances between New York and Chicago, by way of the principal rail lines, vary from 908 to 1013 miles, while between these airports the airline is 712 miles, a shortening of the distance to be traveled by from 196 to 301 miles.

The schedule between New York and Chicago by extra-fare train is 20 hr.; 26 years ago the time was 2 hr. shorter. Today, the regular-fare train takes 28 hr. The fare on the regular train is $32.70, while on the fastest extra-fare train it is $42.30. The saving of 8 hr. on the extra-fare train is at a cost of $9.60, or at the rate of 2 cents per minute. The Pullman fare will average $8.46, based upon the use of 80 per cent of the lower and 20 per cent of the upper berths. Three meals will cost at least $3.75, making a total of $45.09 on the regular-fare train, and $54.69 on the extra-fare train. This is the equivalent of 6 cents per mile via the shortest rail route. Expanding the idea of 2 cents per minute for the time saved, 10 hr. more saved by airplane would amount to $12.00, which, added to the extra-fare train cost would be $66.69, and is equivalent to 9.3 cents per airline mile.

The airway rate announced by one company will be $100.00, equivalent to 14 cents per airline mile. The service will save 18 hr. over the regular-schedule train, and 10 hr. over the extra-fare train, allowing for the time going to and from the airports.

In the case of the typical extra-fare train operating between New York and Chicago, there is not sufficient time to clean and make ready an arriving train for return the same day; so an extra set of equipment and five locomotives are required for each one-way trip. This represents an investment of approximately $1,000,000, or $10,000 per passenger. With a 12-passenger airplane and necessary spare engines and accessories costing $80,000, and carrying an average of nine passengers, the investment is $8,888 per passenger. However, with spare parts and adequate facilities, the airplane should make a round trip to Chicago daily, and then the investment would be $4,444 per passenger, or 56 per cent less than the steam-train investment.

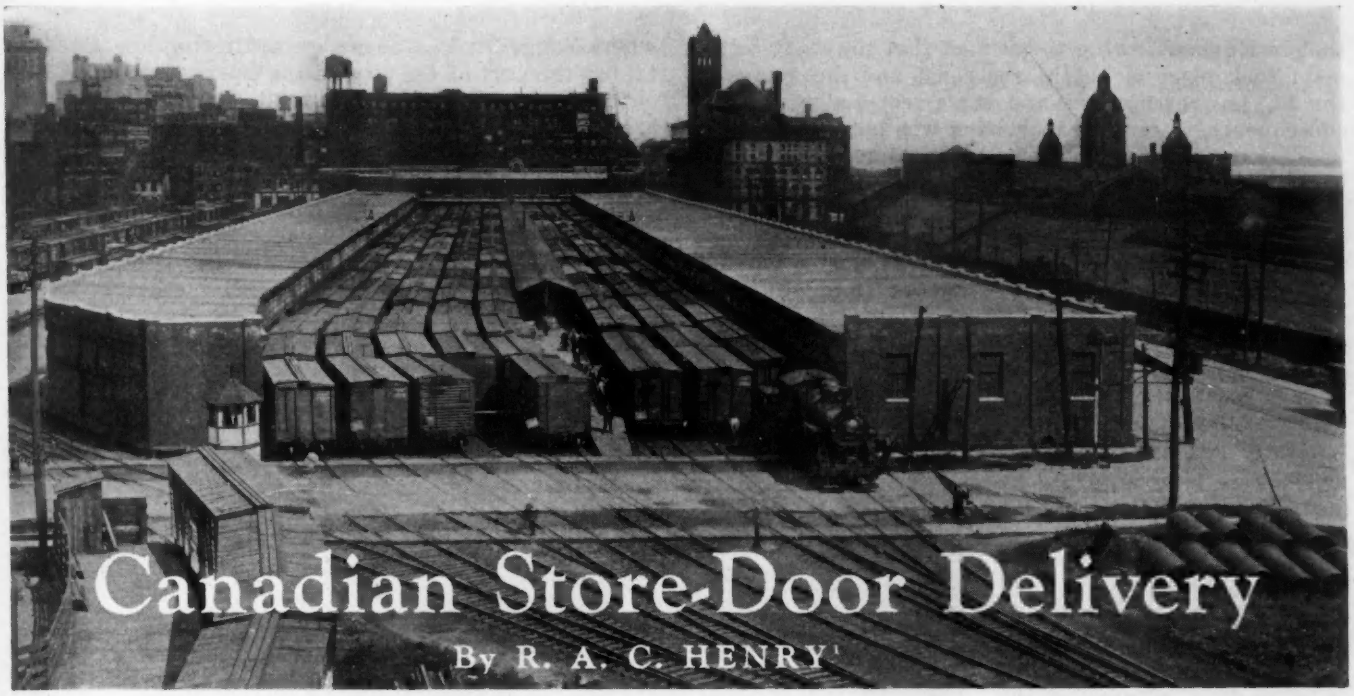
The steam passenger-train moves 15.1 times as much dead weight per pound of pay-load as does the airplane. A horsepower-hour of steam locomotive moves 6.1 times as many ton-miles of pay-load as does the airplane, but the steam locomotive has to move its pay-load, as well as a very much greater proportion of dead weight, about 27 per cent farther than the airplane, and it does it at about one-half the speed.

TOTAL WORK DONE

Equating for the weight and distance under the conditions considered, for each passenger moved between New York and Chicago the steam train makes 113 ton-miles of pay-load, 9462 ton-miles of dead weight, or 9575 gross ton-miles. The airplane makes 71 ton-miles of pay-load, 396 ton-miles of dead weight, or 467 gross ton-miles. The steam train makes 20.5 times as many gross ton-miles as does the airplane. The steam locomotive using 10 hp. per passenger and taking 20 hr. does 200-hr. of work in moving 9575 gross ton-miles, or 47.5 gross ton-miles per horsepower-hour. The airplane uses 102 hp. per passenger and, taking 7¾ hr., does 790 hp.-hr. in moving 467 gross ton-miles, or 0.6 gross ton-miles per horsepower-hour. This means that a horsepower-hour of steam locomotive, in the case cited, will move about 80 times as many gross ton-miles as will the airplane. However, as the steam train moves 20.5 times the gross per unit of pay-load, it resolves itself into the airplane having to do only 3.9 times the work of a steam locomotive in overcoming gravity and moving its pay-load 107 per cent faster.

In its initial operations, the airplane will carry practically twice as many passengers per crew employe as do the steam roads. This will vary as the size of planes increases, and in a manner favorable to the plane. Labor is an important part of the cost of operation and in this respect the airplane has the advantage.

To the student of transportation, the relationships shown point to factors upon which greatest stress should be laid to improve service and reduce costs of operation. The aviation field is an inviting one, and, dependent upon the soundness of preliminary developments and the thoroughness with which it is administered, will the growth be rapid, substantial and profitable.—N. D. Ballantine, in *Airway Age*.



Canadian Store-Door Delivery

By R. A. C. HENRY[1]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS AND FORMS

AFTER defining the meaning of store-door delivery and outlining its history in Canada, the author reviews in detail the functions of the cartage agent and the railroad company under that system, and gives an idea of the territory and population served.

Operation of Canadian store-door delivery is fully described, both as to the terminal facilities and the methods of handling, recording and checking outbound and inbound freight shipments. The author shows that in eastern Canada more than 97 per cent of the carted inbound tonnage is delivered to consignees by the end of the day following its receipt at the railroad sheds.

Cartage tariffs used in Canadian store-door delivery are given and the legal situation involved in the operation of cartage service by railroads is outlined. It has been decided that such service is not a railroad facility over which the Board of Railway Commissioners of Canada has jurisdiction, therefore the operators of the cartage service have the power to delimit this service and to fix rates therefor.

In conclusion, it is stated that during more than 70 years Canada has grown accustomed to store-door delivery and that the advantage taken of such service by the shipping public seems to indicate that the people approve it, at least in principle.

THE term "store-door delivery" as used in Canadian railway parlance is intended to describe a type of service performed in connection with the collection and distribution of freight traffic handled by railway companies in large centers of population. This term refers to the function of moving freight from the terminus of the delivering railway carrier to the exact premises of the consignee on incoming traffic by rail, and from the premises of the consignor to the terminus of the receiving rail carrier on traffic that is outbound by rail.

The function itself is not now performed by the railway companies themselves as railways, but is performed either through subsidiary companies controlled by the railway companies or by private companies over which the railways have a large measure of control through agreements which specify the nature of the service to be rendered and the rates to be charged for such service.

History of Development

In England, for more than a century before the inauguration of steam railways, Pickford & Co. were the principal carriers, and they transported merchandise by canal boats, stage-wagons, vans and carts between London, Birmingham, Manchester, Liverpool and other large towns. The van operated over the turnpike road at what was, in those days, a rapid rate of speed and carried the small parcels and the more valuable freight. "Pickford's Van," in fact, became a household phrase.

When the success of the steam railway became apparent, the old carriers, realizing that they would soon lose their business to this new transportation agency, decided to cooperate with it to as great an extent as possible and undertook to do terminal work for the railways, more particularly the collection and delivery of railway freight in the larger cities. This business developed rapidly and really established what we now call "store-door delivery."

In Canada the position was somewhat different from

[1] Director, bureau of economics, Canadian National Railways, Montreal, Canada.

that in England, owing to the fact that the early settlement took place along the sea coast and the shores of the St. Lawrence River and the Great Lakes, and, in consequence, water transportation was largely depended upon; but the freight van was used to some extent for distribution of freight to interior points, as the stage coach was used for the carriage of passengers.

The earliest efforts at railway construction in Canada were centered around Toronto, Hamilton and London, in Upper Canada, now the Province of Ontario, by the Great Western Railway, and around Montreal, in Lower Canada, now the Province of Quebec, by the Champlain & St. Lawrence and the St. Lawrence & Atlantic Railways, which were later absorbed by the Grand Trunk Railway. The construction of these railways was financed by English capitalists and they were managed by English officers. It is not surprising, therefore, that they adopted the policy of store-door delivery at the earliest opportunity.

The Great Western Railway had employed, as contractors, two young Scotsmen, William Hendrie and John Shedden, who had an ambition to become the "Pickford's" of Canada, and in 1855 they became partners in a cartage business to perform store-door delivery for the Great Western Railway in Toronto, Hamilton and London. In 1856 the Grand Trunk Railway completed rail connection between Montreal and Toronto, and Messrs. Hendrie and Shedden became the official cartage agents for that railway, as they already were for the Great Western Railway. They opened offices in different cities, notably in Montreal, Toronto, Hamilton, Brantford, Guelph and London, and introduced a suitable wagon for moving heavy merchandise in place of the small and inconvenient carts previously employed. Each wagon was provided with a good waterproof cover to keep the goods dry. At this time a blank shipping note with duplicate stubs was given to the merchants and proved a most useful and needed reform. Previously, with the exception of a few of the larger merchants, shipping notes were made out on the first scrap of paper to hand—an old envelope or the corner of a newspaper—and were a bugbear to the shipping clerks who had to decipher them by gaslight or oil lamp.

Hendrie and Shedden remained in partnership until 1873, when they separated amicably. Hendrie founded William Hendrie & Co. and became the official cartage agent for the Great Western Railway, while Shedden founded the John Shedden Forwarding Co. and performed cartage for the Grand Trunk Railway Co. of Canada. In 1884 the Great Western Railway was acquired by the Grand Trunk Railway, but the cartage arrangements remained the same, except in Toronto, where Yonge Street was made the dividing line, Shedden taking the part of the city on the east and Hendrie that on the west side of Yonge Street. Both of these firms are still in operation, although the name of the former has been changed to the Canadian Cartage & Storage Co.

The Canadian Pacific Railway early organized a subsidiary company—the Dominion Transport Co.— to perform store-door delivery for it; and similarly the Canadian Northern Railway formed the Canadian Northern Transfer Co., now known as the Canadian National Transfer Co.

FIG. 1—TORONTO INCOMING-FREIGHT SHED FROM STREET SIDE
Contract Carters' Vehicles Receiving Consignments at Designated Doors

It has seemed to me desirable, in approaching this subject, to explain it in as complete detail as possible. Before going on, I may state that I am describing more particularly the operation on the Canadian National Railways, because that is the only company for which I have any data.

METHOD OF PERFORMANCE

The Grand Trunk and Canadian Northern Railway systems, which have become part of the Canadian National Railways, while recognizing the necessity for store-door delivery, had such service performed each in a different manner. The Grand Trunk Railway Co., as explained, followed the English practice of appointing cartage agents in the larger centers. The Canadian Northern Railway had its origin in western Canada and organized a subsidiary company—the Canadian Northern Transfer Co.—to perform such service in Winnipeg, and later in Montreal and Toronto. Upon amalgamation, these two methods were, and are still, in use by the Canadian National Railways, although the Canadian Northern (now the Canadian National) Transfer Co. has sold its rights in Winnipeg and operates only in Toronto and Montreal.

While of necessity the contracts with official carters

vary according to location, the salient features are the same and include the following:

The cartage agents agree on their part to

(1) Be responsible for any loss of or damage to goods while in their charge or for any loss to a consignee or consignor by reason of any undue delay in delivery
(2) Be responsible for the collection of all charges on the delivery sheets and for the obtaining of consignee's signature upon delivery
(3) Carry goods to whichever shed they are directed in cases where the railway has more than one shed in a city
(4) Furnish sufficient equipment and men to avoid unnecessary delay in delivery or collection
(5) Load and unload their vehicles from or to the floors of sheds, platforms or cars
(6) Adhere to hours of delivery and receipt of shipments prescribed by the railway company
(7) Perform cartage services at schedule rates
(8) Use only the stationery and forms provided by the railway
(9) In some cases, not to carry goods for other railway companies

Fig. 2—Interior of Toronto Incoming-Freight Shed
Car Doors Are "Spotted" Opposite Shed Doors on the Right and Carters' Trucks Take Consignments for Delivery from Doors on the Left

The railway company, for its part, agrees to

(1) Provide reasonable appliances for loading and unloading carters' vehicles but not to be expected to assist in such operations
(2) Supply a sufficient number of checkers and freight handlers so as not to unduly delay teams
(3) Provide all necessary books, notices, forms of receipt, advice and shipping notes, delivery sheets, and the like
(4) Provide reasonable office space on the company's premises for the carter's agent
(5) Promote cartage business to a reasonable extent
(6) Transport the carter's equipment and so forth at half rate, should such movement be necessary

The railway company reserves the right, in the event of persistent undue delays in delivery, to put on necessary men and equipment at the carter's expense until the condition is remedied, reasonable allowance being made for climatic and other delays beyond the carter's control.

Territory Served

The Canadian Northern Transfer Co. was incorporated by the Canadian Northern Railway Co. in 1903 for the purpose of performing store-door delivery. There was not a sufficient number of large cities in western Canada at that time to warrant the establishment of services by this company except in Winnipeg. Later, in eastern Canada, branches were established in Montreal and Toronto, and the rights in Winnipeg were disposed of to a private cartage firm. At present, cartage service is performed for the Canadian National Railways in the provinces and communities shown in Table 1.

The only practical differences between operators in eastern and western Canada are:

(1) In the West the teaming companies issue rate schedules themselves.
(2) In eastern Canada incoming freight is taken by the cartage company for delivery, without advice from the consignee, only when such consignee has a credit with the railway company; while in the West incoming cartage freight is given to the official carter without any order from the consignee, unless definite instructions are issued to the contrary.
(3) In eastern Canada the agents collect charges on all goods they deliver regardless of whether the consignee is on a credit list; while in the West the railways collect from the consignees on the credit list the charges on goods the carters deliver. This means that the railways collect most of the charges.

Shippers of outbound freight are provided with blank shipping bills in triplicate, numbered 1, 2, and 3. No. 1 is designated "Straight Bill of Lading—Original. Not Negotiable;" No. 2 as "This Shipping Order;" and No. 3 as "This Memorandum."

These forms, as indicated thereon, have been approved by the Board of Railway Commissioners for Canada. As filled out in triplicate by the consignor, they show the name of the consignee, the destination, the number and weight of packages, a description of

TABLE 1—COMMUNITIES IN WHICH CARTAGE SERVICE IS PERFORMED FOR THE CANADIAN NATIONAL RAILWAYS

Province	City or Town	Population
Quebec	Montreal	1,000,000
	St. Hyacinthe	12,000
	Valleyfield	9,000
Ontario	Toronto	775,000
	Hamilton	150,000
	London	85,000
	Brantford	37,000
	Guelph	23,000
	Windsor	52,000
	Walkerville	7,500
	Chatham	19,000
	St. Catharines	22,000
	St. Thomas	17,000
Manitoba	Winnipeg	192,000
	Brandon	16,500
Saskatchewan	Regina	38,000
	Moose Jaw	19,000
	Saskatoon	31,000
	North Battleford	5,000
Alberta	Calgary	65,000
	Edmonton	65,000
British Columbia	Vancouver	215,000
	Total	2,854,000

the goods, and indicate whether charges are prepaid. If the shipper does not do his own cartage, he notifies the railway company of his intending shipment and arrangements are made for collection of the freight by the official carter's representative, who has office space in the railway's freight sheds. Upon reaching the freight sheds, the same procedure is followed by all

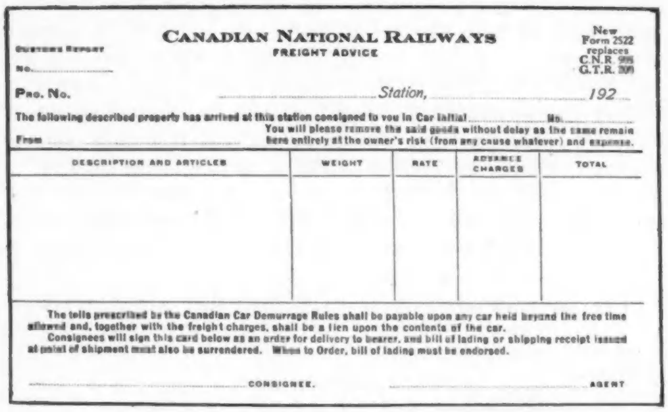


FIG. 4—ADVICE-NOTE FORM FOR CONSIGNMENTS RECEIVED

When Filled in, a Copy Is Given to the Carter's Agent, Who Assembles the Goods by Zones and Arranges for Their Delivery to Consignees

carters. In the case of carters of the official cartage agency, however, familiarity with the location of the berth cars tends to speed up the movement.

TYPICAL FREIGHT-TERMINAL LAYOUT

The King Edward freight yards of the Canadian National Railways in Toronto, shown in the frontispiece hereto, may be taken as typical of such yards. There are eight tracks, with freight sheds on either side and a covered platform between the tracks. The shed on the left is for the receipt of outbound freight, and the cars on the adjacent five tracks are outbound. On the right of the central covered platform are three tracks for inbound freight. The central platform is to provide shelter for goods which have to be trans-shipped, and which are unloaded to this platform and reloaded to their proper berth cars. Freight that has reached its destination is unloaded to the shed on the right. The sheds on either side of the yard are similar, so a description of one will suffice.

In Fig. 1 the street side of the receiving shed at Toronto is shown. Sheds are long and have large sliding doors at intervals of 30 ft. or so for their entire length. Directly opposite these doors are corresponding doors on the track side of the shed. The interior of the Toronto freight-receiving shed is illustrated in Fig. 2.

Cars on each track in the yard are "spotted" with their doors as nearly as possible opposite each other and also opposite the doors in the track side of the freight shed, so that, by laying light movable platforms between the doors of cars on the various tracks, freight can be wheeled direct from the floor of the shed to any car opposite any door. The yard superintendent prepares a loading chart, on which each door of the receiving freight shed is shown by num-

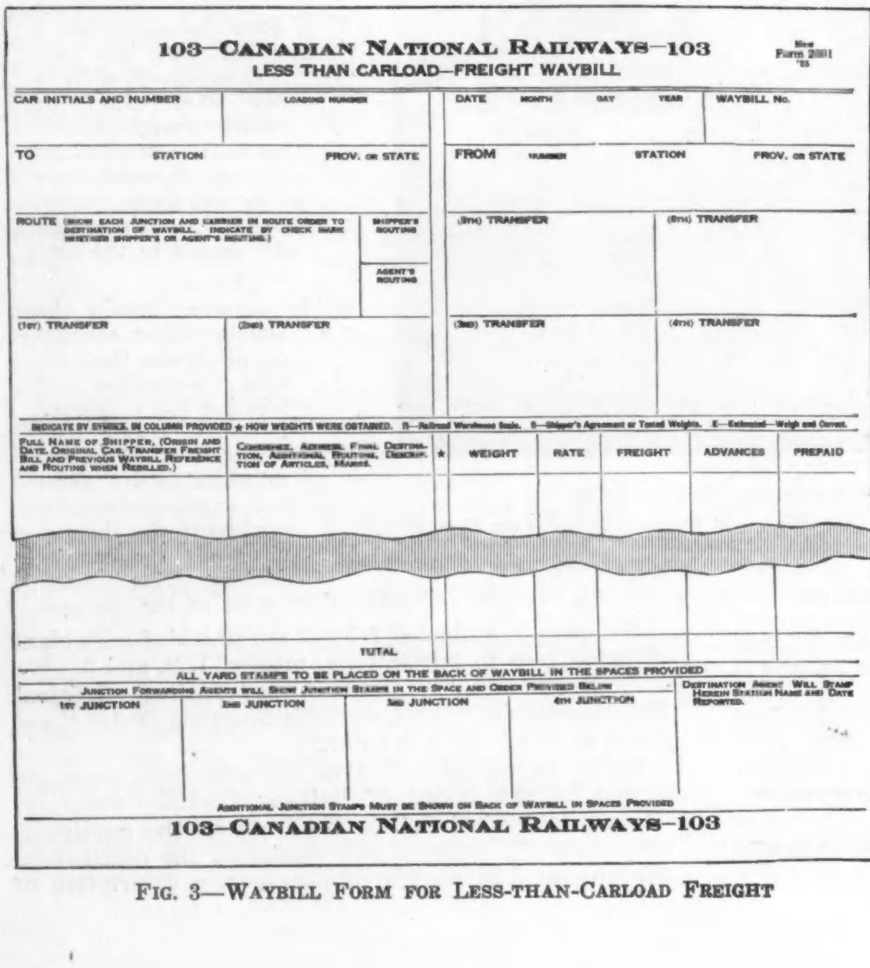
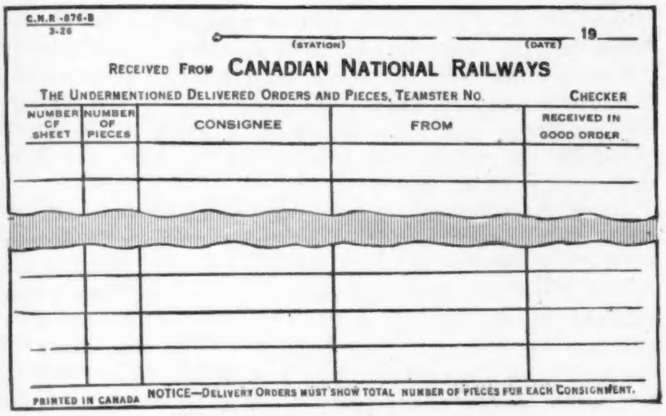


FIG. 3—WAYBILL FORM FOR LESS-THAN-CARLOAD FREIGHT



C.N.R.-876-B
3-26

_____ (STATION) _____ (DATE) 19___

RECEIVED FROM CANADIAN NATIONAL RAILWAYS

THE UNDERMENTIONED DELIVERED ORDERS AND PIECES, TEAMSTER NO. ___ CHECKER

NUMBER OF SHEET	NUMBER OF PIECES	CONSIGNEE	FROM	RECEIVED IN GOOD ORDER

PRINTED IN CANADA NOTICE—DELIVERY ORDERS MUST SHOW TOTAL NUMBER OF PIECES FOR EACH CONSIGNMENT.

FIG. 5—CARTER'S-SHEET FORM
This Shows a Complete Record of Goods Given to Each Carter and Constitutes the Railroad Company's Receipt

ber and the destination of all cars opposite each door is indicated. When there is not sufficient freight to warrant loading a whole car for any one destination, cars are subdivided for different adjacent destinations on the same line. These loading charts are of the greatest importance, and a sufficient number of copies are prepared for distribution among shed foremen, checkers, billing clerks, and others.

It is probable that any peculiarity or distinction possessed by our yards over similar yards in the United States lies in their size. Reference to the amount of freight handled across the floors will be made later.

OUTBOUND-SHIPMENT OPERATION

The carter, upon arriving at the freight shed with his shipment, reports to the shed foreman and gives him the shipping bills. From examination of the destinations of shipments as shown on the shipping bills and from reference to the loading chart, the shed foreman marks on each bill the door or berth number for each shipment, and the carter unloads at the correct doors goods for each destination.

The checker stationed at the shed door receives the shipping bills, checks them as to number of packages and berth number, and receipts all three copies, retaining No. 2 and returning Nos. 1 and 3 to the carter as his receipt. The weights of shipments are checked and the freight handlers load the goods to the right car under the checker's direction. The checker then places the car number and initial on his copy of the shipping bill. The bills in the hands of checkers are collected at intervals and given to the billing clerk, who classifies, rates and extends the charges on shipment, and at the same time checks the berth number of the shipment from his copy of the loading chart. The shipping bill passes to a revising clerk for check and then goes to the billers, who make out waybills (Fig. 3) in quadruplicate.

To save time and stationery, a blanket waybill is frequently used where there are several shipments for the same destination, not necessarily from one consignor or to one consignee, but showing shipments from origin "A" to destination "B," all in one car. The quadruplicate copies of each waybill are distributed one each to the division freight agent, the accounting office, the car containing the shipments, and copy is kept for record in the local freight office.

At the conclusion of a day's loading, the waybills are sorted according to car numbers, and those for covering shipments contained in each car are placed in an envelope and sent to the yardmaster's office, where, after checking, they are delivered to the train conductors when the train is made up and despatched.

PROCEDURE WITH INBOUND FREIGHT

With the arrival of cars in a terminal yard, the conductor delivers his waybills to the yard office, the cars are marked for switching and the bills sent to the local freight office. The cars are "spotted" at the sheds and goods are unloaded and checked with the waybill, which then goes to the advising clerk, who makes out advice notes (Fig. 4) in quintuplicate. The waybills are then checked to discover if the consignee has a credit with the railway company or has issued any delivery instructions. The procedure described is that followed in eastern Canada, which is somewhat different from that in the West.

If there is cartage freight and the consignee has a credit with the railway company, the advice note is sent to the shed office, where the berth or the door number opposite which the goods have been unloaded is placed thereon. The notes then pass to the cartage company's agent on the premises, who assembles them by zones and arranges for delivery. The carter receives the advice notes, collects his load, signs for the shipments taken, and returns to the railway office to be "sheeted."

The carter's sheet (Fig. 5) shows a complete record of goods, and the total charges against them, given to each carter and received by him in good order. The

FIG. 6—UNLOADING, CHECKING AND WEIGHING INCOMING FREIGHT
Berth Cars Are Unloaded Through the Doors on the Left, the Shipments Checked, Weighed, and Finally Taken Away on the Right by Carters' Truckmen

cartage company's agent then makes up his delivery sheets from these carter's sheets, and the carter proceeds with delivery. If, however, the consignee has not a credit with the railway company, an advice notice is mailed to him.

Fig. 6 shows consignments being wheeled into the Toronto freight shed from the berth cars, and the checkers at work. A waiting wagon is seen backed up to the first door on the right.

Effectiveness of Service

The effectiveness, or perhaps the benefits derived from the store-door delivery service, may be considered from several points of view: (*a*) the extent to which it is used by shippers, (*b*) the dispatch with which the freight sheds are cleared, and (*c*) the floor area required per ton of freight handled.

To ascertain the extent to which the service is used by the shipping public, a study was made of the situation in Montreal, Toronto and Hamilton, from which the data in Table 2 on l.c.l. freight handled by the official cartage companies were obtained.

TABLE 2—PERCENTAGES OF TOTAL L.C.L. FREIGHT HANDLED BY OFFICIAL CARTAGE COMPANIES

	Into Freight Shed	Out of Freight Shed	Total
Montreal	55.9	77.65	64.1
Toronto	57.8	72.8	63.1
Hamilton	63.1	71.4	63.1

It will be seen that the cartage companies' agents handle a much greater proportion of the total freight from the freight sheds than to them. This may be accounted for in two ways:

(1) The cartage companies, being assured of a certain amount of business through their contracts with the railway company, do not solicit business activity but wait for telephone orders on business to the freight sheds, as these cartage agents are not an integral part of the railway with which they are allied and are not directly concerned with increasing the railway's business

(2) Inroads on the business are made by the private trucker, who in many cases renders the service at a very low cost

The dispatch with which sheds are cleared indicates the service rendered to the public, on the one hand, and the use made of the shed facilities, on the other hand. The average time required for distribution of consignments received per day is shown in Table 3. Store-door delivery is rendered in Montreal by both a subsidiary of the railway company and a cartage agent; in Toronto by two cartage companies and a railway subsidiary company; and in Hamilton by a cartage company.

TABLE 3—AVERAGE TIME REQUIRED FOR DISTRIBUTION OF CONSIGNMENTS

Delivery after Receipt by Railway Company	*Montreal* Consignments	*Montreal* Per Cent	*Toronto* Consignments	*Toronto* Per Cent	*Hamilton* Consignments	*Hamilton* Per Cent
Same Day	329	19.8	265	21.7	92	26.4
1 Day After	1,198	72.2	712	58.4	245	70.4
2 Days After	85	5.1	216	17.7	8	2.3
3 Days After	21	1.3	25	2.0	3	0.9
4 Days After	...	...	2	0.2		
5 Days After	27	1.6				
Total	1,660	100.0	1,220	100.0	348	100.0

Summarizing the delay at the freight sheds in the three largest cities in eastern Canada, we find that in Montreal and Toronto more than 97 per cent of the inbound carted tonnage is delivered to the consignees by the second day after its receipt; while in Hamilton virtually the whole inbound carted tonnage has been delivered in this time.

Attempts made by the railway companies to discontinue the service, because of petitions made to the Board of Railway Commissioners, have been very strenuously opposed by the shipping public. Such service is invaluable to the shippers, as it tends to make possible the cutting down of stock because of the confidence in the ability of the carrier to give dispatch. The railway company, on the other hand, is able to coordinate its road service with its terminal service without undue delay or congestion.

During the Interstate Commerce Committee investigation of motor-truck and motorcoach operation in the United States, it was revealed that 32 per cent of all railway damage claims were paid on l.c.l. freight. Under such conditions, the value in dollars and cents of having goods delivered to consignees as quickly as possible after arrival at the terminal sheds cannot be computed, but is very considerable. I understand that in Canada the loss and damage claims on l.c.l. freight amount to about 22 per cent of the total.

Floor Space Per Ton Handled

While I have no data available regarding the rate at which freight is handled through the sheds of railways which do not offer store-door delivery, the performance by the Canadian National Railways is indicated by the following figures:

	Floor Space per Ton Handled, Sq. Ft.
Toronto	174
Montreal, Bonaventure yards	133
Montreal, Moreau Street yards	175

Cartage Tariffs

Previous to 1893, railway freight rates on commodities classifying first to fifth classes included the cost of cartage at origin and destination in the larger centers where the railway (the Grand Trunk) had cartage agents. Freight classifying sixth to tenth classes was subject to additional expense for cartage. In 1893 the following charges were added to the freight rates at either or both ends when cartage service was undertaken by the railways, the total charge not to exceed fifth-class rate plus 1 cent per 100 lb.:

Classes	Cartage Charges per 100 Lb., Cents
First to Fourth	1¼
Fifth	1
Sixth to Tenth	2½

In 1903 the cartage charges were advanced slightly and rearranged as follows, the total charge not to exceed fifth-class rate plus 1½ cents per 100 lb.:

First to Fifth	1½
Sixth to Tenth	2

During the above period, a cartage clause was carried in our various class and commodity tariffs in which

the charges and information in connection with this special service were shown. Beginning in 1924, and since that date, cartage charges and information in connection with this service have been omitted from our freight tariffs and a special cartage tariff is published covering these arrangements. The practice of publishing cartage tariffs obtains today in eastern Canada; in the territory west of Port Arthur, such tariffs are not issued by the carriers. Cartage rates to and from some of the principal terminals, covering delivery within a radius of approximately 2½ miles from the terminals, are given in Table 4. The same cartage rates prevail on outbound shipments moving from consignors to the railways freight sheds.

Montreal Conditions Adverse to Motor-Trucks

Most of the accompanying illustrations do not show motor-trucks used for store-door delivery. Motor-trucks are not used in Montreal to as great an extent as in other places, as the streets are very congested. The Canadian Cartage & Storage Co. finds that the time consumed in loading and unloading at the various points is so great that it is not economical to use motor-trucks. Trucks are, however, being brought into use to a considerable extent in Toronto and Hamilton, as well as in the western provinces.

Railroad Board Lacks Authority Over Cartage

The Board of Railway Commissioners of Canada corresponds in some respects as to its power and jurisdiction with the Interstate Commerce Commission in the United States. Since the creation of the Board in 1903, the railway companies have been careful to separate the functions performed by the cartage companies in connection with store-door delivery from the railway services manifestly covered by the railway rate-tariffs and have consequently held that the Board of Railway Commissioners has no authority over cartage rates or over cartage service.

In 1919, upon complaint by the Toronto Board of Trade against the cartage tariffs of the railway companies, the Board of Railway Commissioners decided to hold hearings for the presentation of any evidence relevant to such matters, and during the hearings the question as to the effect of an amendment to Section 312 of the Railway Act of 1919, on the powers of the Board in respect to cartage service performed by the railways, was raised. The section of the Railway Act, as it existed prior to 1919, dealt with the facilities to be afforded by a railway company and was amended in the Railway Act of 1919 by the addition of Clause (*e*) Sub-Section (1), as follows:

> The railway company shall according to its powers . . .
>
> (e) Furnish such other service incidental to transportation as is customary or usual in connection with the business of a railway company, as may be ordered by the Board.

Under the law prior to 1919, it was held by the Board of Railway Commissioners that the charge for cartage came within the definition of "toll," as set out in the interpretation section of the Act, but that cartage service was not a "railway service or facility" within the meaning of the Act. The appeal by the Toronto Board of Trade was dismissed on the grounds that the Board had no jurisdiction over such cartage charges.

TABLE 4—MINIMUM CARTAGE CHARGE FOR ANY ONE CONSIGNMENT

	Per 100 Lb., Cents		300 Lb.	Over
	Carloads	L.C.L.	and Under	300 Lb.
Montreal	5	7	30	40
Toronto	4	6	30	40
Chatham	4	5	30	40
Guelph	4	5	30	40
London	4	5	30	40
Ottawa	4	5	30	40
St. Hyacinthe	4	5	30	40
St. Thomas	3½	4	25	35
Hamilton	3½	5	30	40
Windsor	3½	5½	35	50
St. Catharines	3½	5	30	40

Following this decision the cartage service was continued, the burden of cost being borne by the users thereof. The tariffs showing the charges for cartage service have been filed simply for the information of the public and as indicating the charges at which, under contracts entered into, the cartage companies are prepared to carry on this service. In connection with these cartage tariffs, there is a practice of excepting various articles that are light and bulky or which have other characteristics which the cartage companies contend preclude the possibility of their being carried at the general scale of rates. Where there are such excepted articles, the determination of the charge made for the service is dependent upon individual contracts.

Conclusion

It must be acknowledged that the movement of merchandise between a consignor and a consignee is not complete until delivery has been made at such consignee's door. In these days when speed between origin and destination is so important, anything the railways can do to decrease the time consumed in the shipment of freight—not merely between railway terminals but to the actual door of the consignee—will redound to their credit and tend to increase business. It may be said that no storage charges can sufficiently compensate a railway company for the space occupied and that the present cost of handling freight through terminals warrants the railways making every possible effort in expediting its movement from such terminals.

As we have seen, in eastern Canada approximately 65 per cent of the total l.c.l. shipments in the three largest cities moves through store-door delivery, which indicates that the public will take advantage of such service if offered. Our freight sheds are relatively small for the volume of business handled, while the vehicles carting merchandise to and from the railway sheds are well loaded and consequently congestion is considerably reduced. Attention has been called to the time-cycle of delivery from the sheds, which increases their capacity to an enormous extent. The decrease in damage claims on l.c.l. freight, by virtue of this quick and reliable delivery from the sheds, cannot be approximated.

We have had store-door delivery in Canada for more than 70 years. We have grown accustomed to it, and the advantage taken of such service by the shipping public, even in these days of private motor-vehicle ownership, seems to indicate its approval of the principle at least.

THE DISCUSSION

CHAIRMAN F. C. HORNER[2]:—Mr. Henry has given what I consider a comprehensive picture of what Canadian store-door-delivery service of today is. Our problem, as I see it with reference to the matter of clearing the freight through the terminal, is basically the same as the problem in Canada and in England, in spite of certain things that change the situation as the fact, mentioned by Mr. Henry, that in Montreal very few motor-trucks are in use, the vehicles being mostly horse-drawn.

The four parties principally interested in this matter are the railroads, the merchants, the cartage men, and the public.

GEORGE W. DANIELS[3]:—I believe that the solution of the problem of congestion, not only on the piers of all the railroad lines in New York City, but on the streets, is store-door-delivery. The big manufacturing centers in New York City, such as the garment center, and the wholesale districts, are innumerable congested points. Buildings in these districts house from 10 to 20 tenants. Some receive one case at a time and others ten, and probably every tenant uses a different truckman. Often the goods are brought from mills having a truckman in the city who delivers for them. That adds other truckmen. Trucks are now loaded at night for the uptown section, and the man who gets to the door first is lucky. If he has to make two deliveries in one building, he can make one promptly, but while his receipt is being signed another truckman beats him out on the second delivery, so he must lose from ½ to 1½ hr. to make the second delivery.

In any new building of more than one tenant the ground floor should be devoted entirely to the receipt and shipment of merchandise, the raw material going into and finished products coming out of that building. I believe there should be one truckman for each building. This man would bring all goods to that one building and he would use only one, two or three trucks where ten create a congestion at present.

Or consider the hotels in New York City. Buyers from the McAlpin, for example, go to the market, and I venture to say that often a dozen wagons drive up to the hotel door on 33rd Street, one of the narrowest streets in the busiest section, during the day.

Congestion is costing the railroads, merchants and truckmen money. We try to get as much of ours back as we can, but it is a difficult matter to show black figures all the time.

In 1918, when we had the Railroad Administration, Judge Harlan came to New York, under the direction of Mr. McAdoo, then Railroad Administrator, and tried to inaugurate store-door delivery. Early in November, 1918, it was finally agreed to put it into operation on Dec. 1. Unfortunately for store-door delivery, the armistice came on Nov. 11 and killed the plan. I am satisfied that, had store-door delivery gone into effect, we should never have given it up.

When goods arrive at New York City, the consignee must remove them at his own expense. Store-door delivery is the proper solution, I think, in spite of much opposition from concerns that own their private vehicles. There is also some opposition from smaller truckmen who claim it will drive them out of business. But all that had been taken care of in the plan worked out by Judge Harlan, whereby everyone was to have a chance to use his own trucks.

NEW YORK'S CONSOLIDATED-CAR SYSTEM

Mr. Henry mentioned 22 Canadian communities having a combined population of 2,800,000. Manhattan has as much and perhaps a little more. While we have not the figures of the tonnage handled through those 22 towns, to anybody who followed recent hearings of the Interstate Commerce Commission on trucking in lieu of lighterage and constructive delivery, the volume of business handled in New York City must have proved astounding.

At present we have a modified store-door delivery that might be termed club-car business. It has grown tremendously in all directions, even faster in the East, I believe, than in the West. I should say that on the New Haven Railroad alone we handle daily from 90 to 120 carload shipments.

In hearing about store-door delivery in Canada, I was struck by the small percentage of the deliveries made on the day of arrival. I cannot understand that, except for a paragraph in Mr. Henry's paper in which he states that only people whose names are on a credit list get the first-day delivery without question, while others have to be notified first. This probably accounts for the delivery on the second day being so heavy. In New York City, with the club-car system, 75 to 90 per cent of the deliveries are made on the day of arrival, and most shipments arrive in the city the day after they are shipped. We often have goods from Boston at the door of the New York consignees before they have received the morning mail, and consequently a truck sometimes is kept waiting pending the making of a decision whether to unload it at the store or deliver it elsewhere. I think that is very good when it is considered that Boston is more than 200 miles from New York City.

Very often, when we receive freight from Holyoke, Mass., which is 160 miles from New York City, we have to wait for the consignees to receive their mail to know what they are going to do with the freight we have ready to deliver. That is what I call modified store-door delivery. It is less-than-carload freight but is shipped in carloads to us at New York City.

I venture to say that our company handles in a day more less-carload freight in New York City than the Canadian National Railways has at all its stations. That shows that there is a tremendous amount of freight movement in New York City, as ours is only one firm among a great many. I think there are about 2000 truckmen in the city.

METROPOLITAN SITUATION IS PECULIAR

J. A. HOFFMAN[4]:—I think that store-door delivery will come very gradually. It is not a matter that we can jump into overnight, by any means. You hear a great deal about the large number of trucks going to piers and picking up only four or five pieces of freight, thereby congesting the piers. It seems to me that there

[2] M.S.A.E.—Assistant to vice-president, General Motors Corp., New York City.

[3] Assistant to president, United States Trucking Corp., New York City.

[4] Vice-president, Motor Haulage Co., Brooklyn, N. Y.

are two angles to that. There is no difference between a truck going to five, six or seven piers, picking up one, two or three cases at each and in the end delivering a solid truckload at one point, and one truck going to a pier, picking up a solid load, and then delivering it in lots of two or three cases to a corresponding number of points at the other end. I believe that we should first attack the carload business, removing it from the pier stations either through the present constructive station or trucking in lieu of lighterage service offered by the carrier on both eastbound and westbound carload freight and then try a similar service on smaller units of say solid truckload lots.

I believe that the conditions existing in New York City, so far as store-door delivery to commercial houses is concerned, are very different from those at any of the points mentioned in this paper. The population of those cities indicates that their business areas must be rather restricted. In New York City we have an entirely different situation. If a concern is doing what we might term a metropolitan business, selling to an area within a radius of 25 or 30 miles from the city and performing its own delivery service, it must necessarily have a large number of trucks to serve that territory daily. To any concern having a metropolitan distribution of products there are therefore decided advantages in doing its own shipping and collecting of its commercial freight, as the trucks used for that purpose in the morning can be utilized later in the day for the metropolitan distribution and cover a greater spread.

There are many merits in store-door delivery, however. We are anxiously looking forward to certain modified forms and are willing to do anything at any time to cooperate with the movement.

Boston & Maine Trucking Service

F. J. Carey[5]:—The definition of store-door delivery, as it is understood by the Boston & Maine Railroad, is precisely that which Mr. Henry has given.

Store-door delivery on the B. & M. did not start out as such but was a by-product of another development which the B. & M. sponsored. For a number of years prior to 1925, the railroad had lost considerable short-haul l.c.l. traffic to the motor-truck. Sensing that shippers and consignees preferred motor-truck service to rail service on such shipments because of the door-to-door service which the trucking companies would give at rates equal to or slightly above the station-to-station rail rates, the B. & M. determined to operate over the highways itself through its subsidiary, the Boston & Maine Transportation Co., on the theory that if the traffic could not be obtained for a rail haul an endeavor should be made to get it for a truck haul.

The most serious truck competition was between Boston and Lowell and Boston and Lawrence. In the spring of 1925 it was announced that the Boston & Maine Transportation Co. was prepared to handle freight in any quantity by truck between Boston, on the one hand, and Lowell and Lawrence, on the other. The service was divided into four classes:

(1) Terminal to terminal, without any cartage
(2) Terminal to terminal, with cartage at one end
(3) Terminal to terminal, with cartage at both ends
(4) Cartage service within each of the three cities.

[5] Manager trucking operations, Boston & Maine Transportation Co., Boston.

Each of the cities was divided into zones, and rates were established varying, first, according to the class of service provided; secondly, according to the zone; and thirdly, according to the weight of each shipment. Since there is no regulation of motor-trucks in Massachusetts except load restrictions and a few safety requirements, the B. & M. Transportation Co. is not obliged to adhere to a single schedule of rates, nor does it do so.

The fourth subdivision enumerated gave an opportunity to satisfy in these three cities what seemed to be an insistent demand on the part of the shipping public for store-door collection and delivery of freight by the railroad, or at least under railroad auspices. Consequently, it was announced that the B. & M. Transportation Co. was prepared to make store-door collection and delivery of B. & M. Railroad freight in Boston, Lowell and Lawrence.

Growth of the Service

The new service was started in May, 1925. In June, the first full month of operation, 13 tons were moved from Boston to Lowell by the B. & M. Transportation Co. for its own account, 4 tons from Lowell to Boston, 25 tons from Boston to Lawrence, and 3 tons from Lawrence to Boston. In Lowell, 48 tons were picked up or delivered locally; in Lawrence, 71 tons. Boston figures are not available.

The volume grew steadily for a time and then met with some setbacks. Independent trucking companies, by cutting rates, regained some of the business they had lost. The store-door collection and delivery of railroad freight did not win favor as rapidly as had been expected. Perhaps it was not pushed strongly enough; but it was the policy of the transportation company not to antagonize local teaming interests, since they can do serious harm to any railroad that seems to antagonize them, especially in a locality where there are competitive railroads.

The B. & M. Transportation Co. makes contracts with existing trucking organizations to perform its trucking. Since it got well under way, the over-the-road service, as we call it, has been profitable both to the contractors and to the transportation company. In September, 1927, 406 tons were hauled by truck from Boston to Lowell; 430 tons from Lowell to Boston; 296 tons from Boston to Lawrence; and 253 tons from Lawrence to Boston. In Boston, 1050 tons were picked up or delivered locally; in Lowell, 639 tons; and in Lawrence, 501 tons.

A few averages may be of interest as indicative of the development of this project.

MONTHLY AVERAGES, IN TONS

	1925[a]	1926	1927	1928[b]
Boston to Lowell	27	135	216	348
Lowell to Boston	58	356	426	389
Boston to Lawrence	49	162	299	215
Lawrence to Boston	153	205	165	217
Boston store-door delivery	...	...	589	864
Lowell store-door delivery	122	454	569	691
Lawrence store-door delivery	233	336	419	477

[a] June to December, inclusive.
[b] January to September, inclusive.

Lowell did not fare as well industrially in 1928 as it did in 1927, which fact explains the drop in the Lowell-to-Boston average for the later period as compared with the earlier one. The drop in the Boston-to-

Lawrence tonnage is due to the return to the rails of some traffic we handled by truck last year and to the cutting of rates by independent trucking organizations.

TRUCKING COMPANY FUNCTIONS INDEPENDENTLY

The store-door service of the B. & M. Transportation Co. is quite independent of the B. & M. Railroad so far as rates are concerned. Rates for store-door collection and delivery are neither included in the rail rates nor added to them by the railroad. In no case is there any mention of or provision for the store-door service in a railroad tariff.

All arrangements for store-door collection and delivery must be made with the transportation company, and charges for service are entirely independent of the railroad freight charges. The transportation company issues its own bills and collects its own revenue. The relations between the railroad and the transportation company are close, however, and at some points B. & M. Transportation Co. bills are made out by the railroad's freight-station force. The transportation company does not sign railroad bills of lading on freight picked up; it functions in this respect exactly as any independent commercial trucking organization.

Since the summer of 1927, the transportation company has extended its activities by handling, for the account of the Boston & Maine Railroad, l.c.l. freight previously handled by rail in line service. This was in principle a station-to-station service, but since it put the transportation company's trucks into many new localities, there was an opportunity for further development of the store-door feature.

The policy has been adopted that, at points where the trucks of the B. & M. Transportation Co. operate, store-door service will be given if the tonnage warrants and if it can be done without impairing truck schedules. Obviously, we cannot have a 5-ton or 7-ton truck running all around in a town delivering or picking up small shipments, but if one concern's receipts or shipments average 1000 lb. or more daily, we generally can arrange to give that concern store-door service. In these communities the principle is the same as at Boston, Lowell and Lawrence. Separate B. & M. Transportation Co. bills are made out and charges are collected by the transportation company over and above any rail freight charges.

In September, 1928, the company collected and delivered tonnages locally in Massachusetts towns as follows: Woburn, 49; Oak Grove, 13; Malden, 10; Graniteville, 10; Watertown, 9; Winchester, 8; Stoneham, 8, and in Ridgemere, N. H., 44 tons. At all these points our trucks handle the l.c.l. freight for the B. & M. Railroad. The figures are not large, but they indicate that a beginning has been made and that the Boston & Maine Railroad, through its subsidiary, is prepared to furnish store-door collection and delivery of l.c.l. feight wherever its trucks operate. It is expected that the trucking of such freight, now confined largely to the Boston suburban district and the Portland, Me., division of the railroad, will be extended to other parts of the B. & M. system, and with it the store-door collection and delivery service.

M. F. STEINBERGER[6]:—Are not the figures quoted representative of the growth in business of a well-financed, well-organized regular motor-trucking company operated in competition with other trucking companies, rather than of the adoption of a pure store-door-delivery program? Is the 48-hr. free-storage time abrogated? Do you handle freight on the blanket order of a shipper? Do you send him a notice first? Will you handle his freight before he receives that notice? In short, are you giving a service that a shipper cannot get through an individual trucker?

MR. CAREY:—Under any arrangement we make to give the shipper or consignee store-door service, we take his incoming freight to his door as soon as it arrives, before any notice except possibly a telephone notice could reach him.

MR. STEINBERGER:—In other words, the Boston & Maine Railroad has gone into the motor-trucking business in competition with other motor truckers.

MR. CAREY:—The Boston & Maine Railroad has gone into the trucking business, competing in some localities with the shipper's own truck, and has effected a saving to the shipper by taking over his truck work at a lower cost.

MR. STEINBERGER:—If the individual trucker would charge the same rates and render the same service that you give, could the shipper not get the same benefit by contracting with the individual truckman?

MR. CAREY:—In a number of rather small localities the tonnage we handle to and from a single concern would not warrant a commercial truckman giving his attention to it. We have made arrangements with tenants of warehouses on Boston & Maine Railroad property whereby we give them store-door delivery. In these cases a complete transportation service is rendered. The Boston & Maine handles their freight by rail, the warehouse is on the railroad property, and the Boston & Maine Transportation Co. delivers it locally.

CHAIRMAN HORNER:—Looking over some of the testimony in the Interstate Commerce Commission hearing on constructive-station operation and trucking in lieu of lighterage at New York City, held some months ago, I noticed that Major C. E. Smith, vice-president of the New York, New Haven & Hartford Railroad, stated that increased use of motor-trucks in coordination with the railroads is necessary if we are to find a permanent solution of these terminal problems. I was very much impressed with that statement and I think we should hear from Major Smith on this subject.

REGULATIONS HAMPER TRUCKING BY RAILROADS

MAJOR C. E. SMITH[7]:—Mr. Henry's paper has been peculiarly satisfying to a railroad man, because it covers the subject thoroughly and tells exactly what his company is doing. Other railroad men, by comparing that report with conditions on their own property, can tell whether and to what extent the service that is being given in Canada could be given here.

I have not been stampeded about the trucking of freight over the highways. It is a question of economics. The average railroad freight-rate charged the shipper today all over the United States is about 1 cent per ton-mile. Manifestly, motor-trucks cannot make any appreciable inroads on railroad traffic moving at that rate. But considerable freight is going to go by truck. Such as is now so moved has been selected by the truckers. They have picked freight that can

[6] M.S.A.E.—Manager highway transportation, Baltimore & Ohio Railroad, Baltimore.

[7] Vice-president, New York, New Haven & Hartford Railroad Co., New Haven, Conn.

be handled readily and cheaply between certain points. They pick commodities most suitable for handling by truck; the remainder does and will continue to remain with the railroads.

If motor trucking continues to increase in volume, the natural result will be a very slight increase in the railroad rates on the traffic which remains, and which would be the great bulk of the traffic, to make up for the loss on the traffic that leaves.

We have found on the New Haven Railroad that the diversion of freight by motor-trucks has merely diluted our railroad freight service. We must continue to serve the same points as formerly and to handle freight that motor-truckmen are not interested in and cannot handle at approximately rail freight costs, but for the handling of which the rates will have to go up in time, to make up for the service rendered on a lighter tonnage.

A very serious factor that is confronting the railroads, and which will keep them from adopting motor-trucks for traffic that can be better handled by motor-truck than by rail, is regulation. At several sessions of Congress, bills have been introduced proposing to place motor-truck operators under common-carrier regulations comparable with those to which the railroads are subjected. Mr. Carey mentioned that the business of the Boston & Maine Transportation Co. between Lawrence and Boston in 1928 dropped off very materially, presumably because of rates being cut by competitive truckers. But railroads cannot cut rates; they are tied hand and foot. If a railroad attempts to establish a motor-truck service and fixes rates which it thinks are just but finds later that these rates are either slightly too high or too low, be the difference ever so little, it cannot change them without appealing to the Interstate Commerce Commission. There ensue hearings which are attended by everybody and his brother and sister, which last several weeks and extend over a year or two. Meantime, the independent motor-trucker can change his rates daily. He can run in fair weather and stop in bad weather. He is not subjected to any of the regulations.

Thinks Industry Should Regulate Trucking

In my opinion, that sort of service is not going to grow as fast as a regulated service that would enable the railroads to adopt motor-trucks in large numbers for the handling of certain classes of freight. I have heard some railroad men who are doing trucking say that they never buy a truck so long as foolish truckmen are ready to do their trucking for them at less than cost.

I think the truck manufacturers must get behind that situation and see that trucking is performed at a remunerative cost, that competitive trucking agencies are not permitted to cut rates on Tuesdays and Thursdays and run at other rates on other days, and to pick the traffic they want and reject what they don't want. If motor trucking were under regulations comparable with those under which the railroads are working, such a balanced situation would enable the railroads to plan their transportation as they would like to, but as they cannot plan it under present conditions.

There is a case in point in New York City today. The railroads started in good faith to extend motor trucking to the greatest degree in the city, with resulting very substantial economy to the shipper. Railroad men differ as to whether there has been any economy for the railroads. However, it is in an experimental stage. Among the factors complicating the situation is the fact that part of the trucking was not under regulation and the truckmen who had contracts to perform the railroad portion of the haul would cut rates beyond that portion. So New York City was about to be deprived of collection-and-delivery service and the railroads filed tariffs cancelling it. The application for the new tariffs was set down for a hearing. Hearings have been held, briefs have been filed, and presently a report will come out and arguments will be heard. In a year or so from now we shall get an answer.

This situation cannot be handled until motor-trucks are under the same regulations as the railroads in handling freight. Then it will be possible to chart the cost indefinitely, with the opportunity for changing the rates when conditions require changes to be made. How soon store-door delivery will come in other cities is equally a matter of regulation.

Conditions Affecting the Truckman

William J. Duffy[8]:—There is a viewpoint that is slightly different from any that has been presented. It is that of the man who actually performs this service. We send a motor-truck to a freight-house to get a shipment for a certain consignee. In that freight-house there are thousands of other shipments; a certain percentage of them have been there more than 24 hr. The greatest delivery of freight in Boston in any one day, so far as I have been able to find out, is approximately 56 per cent of the freight arriving that day. Translating that into terminal facilities, we find that the railroads could get along with a little more than one-half of the present freight-house space, not considering at present the bulk track-facilities for carload deliveries. House facilities for l.c.l. deliveries could be reduced about one-half if regulated store-door delivery of the freight the day it arrives could be inaugurated. I say "regulated" store-door delivery, since in every city in the United States store-door delivery and collection service is in effect from and to the terminal of every railroad.

Store-door delivery is open to so much discussion because this service is not being performed properly in the interests of any of the four parties that Mr. Horner stated are directly affected. As I see it, the chief concern of the railroads in store-door delivery should be the provision of proper terminal facilities and the use of such facilities to the fullest extent, holding down these facilities to the minimum necessary to perform the service properly.

Inefficiency of Present Methods

Fairly large department stores receive, in the course of a day, perhaps 500 or 600 packages. At any department store in Boston, between 6:45 a.m. and 10:30 p.m., five or six trucks are waiting for the truck in front to deliver its load and to move on. The merchant could reduce his necessary facilities and his force and save money if he could receive all of those shipments on one vehicle at approximately the same time of the day.

The truckman has a certain number of customers

[8] General manager, Big 3, Inc., Boston.

from whom he receives orders perhaps 15 or 20 times a day. The first thing in the morning he receives orders to bring freight from the railroad to the consignee's place of business. He picks up the freight which was unloaded the previous day and goes back through the peak of the passenger-car traffic into the city district which is the termination of that traffic to make delivery at the least economical part of the day. After 1 or 2 p.m. the shippers have their goods ready for shipping. The truckman collects a number of small shipments from 15 to 35 shippers, loads a truck and proceeds to the railroad terminals, making deliveries there between 3:30 and 5:00 p.m. Subsequently, the railroad attempts to load each car as fully as possible to the furthest economical destination that same night.

Thus the truckman cannot use the efficiency of which his truck is capable. He drives the empty vehicle from his garage to the railroad in the morning and comes back to the center of the city with a load. Again, he drives from there back to the railroad and returns in the evening, making four trips to carry two loads. This has a direct effect on the public, which attempts to use the streets at the same hours the truckman is performing his store-door delivery.

The problem of the truckman is to get a full truckload to be delivered in the smallest industrial area. This may mean 1 or 10 consignees in one building, or 20 consignees in one city block. When that problem is solved, the almost disastrous effect of motor trucking on the fast street-transportation of the day will have been eliminated.

Approximately 70 per cent of the trucks used in and around Boston run on a competitive basis, carrying less than 1000 lb. to any one destination at any one time. Forty-three per cent of these trucks can carry from 2 to 5 or 7 tons, so the truck is carrying about 28 per cent of its capacity on one trip and is going light one way. About 14 per cent of the usefulness of the truck is realized for about 8 hr., or one-third of the day. Thus, only about 4 or 4½ per cent of the capability of the trucks in a city is realized in store-door delivery under present arrangements, and the railroads have to provide large freight-house space to handle a relatively small quantity of goods.

If regulated store-door delivery should be installed to take care of the smaller shipments not exceeding say 1 or 1½ tons, so that deliveries could be made to the greatest number of consignees in the smallest area at one time, that time being outside the peak hours of passenger transportation in the business and shopping centers, store-door delivery would accomplish a definite step forward for the railroads, the truckmen, the merchants, and the public.

CHAIRMAN HORNER:—From the remarks made it seems more than ever important that, before we arrive at any conclusions, we analyze the problem impartially, not with a predetermined idea that it cannot be solved. In the motor-vehicle business we are constantly confronted with people who say, "It can't be done." C. F. Kettering remarked recently, at the convention of the American Electric Railway Association at Cleveland, that you have to advance a new idea about five years before you can expect it to go into effect. It necessitates a process of education.

[9] Secretary, motor-truck division, National Automobile Chamber of Commerce, New York City.

REGULATION A COMPLEX PROBLEM

E. F. LOOMIS[9]:—The manufacturers of motor-trucks are very conscious of the serious problem to which Major Smith referred. It is created by the number of individual truckmen operating at very low rates, and at rates which are frequently cut. We have had to give a great deal of study to this problem. There was a theory in the truck manufacturing field not many years ago, and some considerable practice founded upon it, that it was good business to place motor-trucks in the hands of former chauffeurs and truck drivers on very small down payments, with the idea that these men would be able to pay for them out of the profits of operation. That theory has been rather well exploded and the practice abandoned to a large extent during the last two years. The trend has been entirely away from it.

If this problem of regulation were as simple as was suggested by Major Smith, I think there would be no difficulty in finding a solution. The farther we get into the problem, the more complex we find it to be, and we welcome any assistance and any suggestions for remedies that our friends in the railroad field can bring forward.

We think that there is a great deal of freight movement by truck today which may not be economical but is the result of public preference for quicker, more convenient and more flexible service than was previously available. We think that a great deal of short-haul freight which is still going by rail will eventually go by motor-truck. It would benefit the shippers, the public and the railroads if the railroads would conduct the motor-truck movement of freight in close coordination with their regular rail movement, and we hope they will go into it.

I do not know how fully the railroad industry realizes that the motor-trucking industry, as it has developed in this Country in 25 years, has been and is a completely individual movement in which it is almost impossible to operate commercially at a substantial profit. For example, a man in the business of hauling for hire is operating equipment at certain costs. Whether or not he is regulated by a State commission and has his rates fixed, he is subject to the competition of the unregulated contract carrier who steps in and offers his largest customers a lower rate.

CANNOT REGULATE CONTRACT CARRIER

The Supreme Court of the United States has several times considered various State regulatory laws and the possibility of regulating the contract carrier, to the extent of requiring him to obtain a certificate of convenience and necessity, file his rates and have them subject to regulation. Every time the question has come up to the Court it has ruled that the contract carrier, under the Fourteenth Amendment to the Constitution, is immune from regulation and cannot be required to take on the characteristics and assume the services of a common carrier. Therefore, in a State which has a fairly good truck regulatory law, the operator of trucks for hire is not only in competition with the railroad but he is subject to severe competition from the contract hauler.

Assuming the possibility of regulating the contract carrier and that the common carrier is regulated, as soon as the truck operator begins to make any substantial amount of money the private business man will

scrutinize closely what he is paying for that service and salesmen for some of the truck manufacturers will tell him that they can provide him with equipment with which he can save a few cents per mile or per ton.

That situation was rather thoroughly exposed in the investigation conducted by the Interstate Commerce Commission under Docket 18,300 about three years ago. Dr. Duncan, an investigator for the American Railway Executives Association, attended those hearings and made a resumé of the testimony which has been widely circulated. Anyone who is interested can secure a copy of that pamphlet by writing to the American Railway Executives Association, City of Washington.

The Interstate Commerce Commission, after reviewing all this testimony and studying the facts, stated officially that in its opinion the time had not yet arrived for the interstate regulation of motor-truck operation.

The trucking business in general is not profitable. A few large commercial trucking concerns are making money because there are some shippers who will pay more than the lowest rate to get reliable and efficient service and full responsibility. There is a field in every city for concerns that will provide this kind of service to build up business and obtain prices for their work that will enable them to make money. The rates probably will be in excess of the cost to the shipper if he owned his own trucks.

In our opinion, the way this problem is going to be worked out, if at all, is through the evolution of State regulation. Of the 24 States that have some form of truck regulation, not one has a law which apparently has not too many loopholes in it. Yet some time a State will evolve a law that will be effective. When we have a workable law, it can be used as a pattern and applied generally to interstate commerce. When that is done it will be beneficial to the truck manufacturers, the truck users, and the railroads.

Small City Truck-Operating Cost

C. S. Burlingham, Jr.[10]:—Our own property operates a street-railway company out of Pittsburgh, with haulage for freight purposes of from 30 to 70 miles. We are about on the point of installing some sort of store-door-delivery system to compete with the contract truckmen in that territory. To get some specific information, I should like to ask this meeting what size of truck would be the most efficient unit in cities of up to 50,000 or 100,000 population, and also if any figures are available as to the probable cost of operation, say in cents per 100 lb.

Mr. Hoffman:—I can cite an instance which we experienced in Jamaica, Long Island, that may be an answer to the questions. The people in Jamaica concluded about a year ago that they would like to have store-door delivery. They invited me to a large conference with the Jamaica Board of Trade, and all were very enthusiastic over the idea. They wanted to know what the service was going to cost. I told them that, to determine a price figure, we needed to know what we had to move. As a result, it was decided that all the merchants of Jamaica would assemble their freight bills for a given period and let us have them for analysis. We tried many times for a month or six weeks to get that data. Finally we had another meeting, to which one concern brought two freight bills, each for a weight of less than 100 lb. Everyone else present said that it did not cost them a cent to pick up their freight at the railroad stations, as they had to have their own trucks for making deliveries to their local customers, and while those trucks were not busy in the morning, during the preparation of the goods to be delivered, they went down to the freight stations and picked up the freight without any cost.

Chairman Horner:—It does not cost anything, according to that. Mr. Burlingham asked specifically regarding the proper size of truck to use and the cost of operating it.

Mr. Daniels:—A 2-ton truck. The operating cost will depend on where and how he takes care of it. The driver's wages must be included. In country towns the drivers of 2-ton trucks receive about $22 a week. Care of the truck will cost about $30 a month. He must also add depreciation. The cost per day, including everything, would be about $15.

Fundamental Differences in Conditions

Billings Wilson[11]:—I should like to ask Mr. Henry how the Canadian railroads resist legal efforts, if any are made, to have store-door-delivery service established in other towns than those the railroad selects.

Mr. Henry:—Attempts of the character you mention have been made from time to time, but there is no authority to which the public can appeal to enforce the establishing of a carting service, because the Board of Railway Commissioners has ruled that it is a railway service which does not come under its jurisdiction and therefore it has to depend upon the judgment of the railway itself as to the desirability.

Mr. Wilson:—Do you mean that it is not possible for a community, through its chamber of commerce, to allege discrimination in that a nearby competitive community enjoys store-door delivery and therefore that its own merchants should enjoy the same service?

Mr. Henry:—They have attempted it, but have never succeeded.

Mr. Wilson:—How do you escape charges of discrimination from someone who is located a block beyond the limits of your store-door-delivery zone?

Mr. Henry:—The limits are defined in the contracts we make with the cartage companies, and the same condition applies there also. There is no authority to which a charge of discrimination can be brought.

Mr. Wilson:—The people in Canada have grown up under this store-door-delivery system from childhood. We in the United States have grown up without it. It is easier to get along with something that you have known from infancy than with something you have not known. Store-door delivery is not a panacea for all ills, however. It will work in a great many cases and in other cases it will not work. In New York City, where we have intense concentration of freight, the railroads have developed their terminal facilities so as to provide deliveries at fixed points around the harbor. In Canada, I dare say, the terminal facilities in most of the important communities have been developed and expanded as necessary, but based on store-door delivery of approximately 70 per cent of the l.c.l. freight. If they did not have store-door delivery they would need more fixed terminal facilities. If we had store-door delivery we should need fewer facilities.

[10] Assistant to president, West Penn Railways Co., Pittsburgh.
[11] Deputy manager, Port of New York Authority, New York City.

If a railroad, having adequate facilities to take care of its business, has store-door delivery superimposed upon it, and if it is unwilling to give up any of its physical terminal facilities and retrench so as to effect the maximum possible economies to be derived from such a venture, it is questionable in my mind whether store-door delivery will be of any real economy to such a carrier.

In attacking the problem of store-door delivery in a city like New York, we should first consider whether certain classes of traffic are growing or declining. It probably would amaze you to know that in certain districts the inbound-freight traffic not only is not increasing but has shown a marked decline in the last five years, brought about by shifts in business, changes in the character of traffic, increase of l.c.l. freight on Manhattan Island, and decrease generally of carload merchandise freight due to large, heavy-tonnage industries moving off the island.

Should Apply New System Gradually

I believe that store-door delivery, properly worked out, will accomplish economies where it is suited to specific problems; but it must be worked out in cooperation with the railroads and the shipping fraternity. I leave out the other two factors Mr. Horner mentioned, because the control of the freight is in the hands of the shipper and the railroad. The motor-trucking agencies are frequently vital factors in soliciting traffic, for one account or another, and that has been one thing that has contributed toward abusive practices; but that can be straightened out. The railroads are going through an experimental stage, just as they did 60 years ago with respect to lighterage. They originally terminated their own operations on the New Jersey side of the Hudson River and employed independent lighterage firms to carry the goods over the river to certain concentration points in Manhattan that were convenient to draymen. For competitive traffic reasons the railroads undertook to extend the lighterage service to other sections of the harbor, where there was a big sugar refinery, for example. The independent lighterman, however, did not find it profitable to run his lighters all over the harbor for the same allowance received for hauling shipments to the rail terminals, and squabbles resulted as to the amount of the lighterage allowances to the independents. The outcome was that the railroads undertook to perform the lighterage service with their own floating equipment.

That may be what we are working toward in the trucking field. In Canada they still seem to be able to get along with the contract truckmen; but I do not believe that contract truckmen in Canada are any more reasonable than those in New York City or elsewhere in the United States.

I should like to see store-door delivery worked out and applied in a scientific way and in an evolutionary manner. We cannot afford to disrupt the terminal machinery that is now handling such a tremendous traffic as daily flows in and out of the port of New York.

Causes of Automobile Breakdowns

THE Get-You-Home service of the Royal Automobile Club provides for the use of a free-relief car to members in the event of a breakdown or accident occurring while they are on the road, and it is from the vouchers filled in in this connection that the Royal Automobile Club compiles the analysis of the causes of breakdowns. The classification is under eight main heads and the more important of these are further classified under sub-heads.

Many thousands of cases are dealt with under this service every year. In the main, the different percentages show very little variation and, in view of the progress which is being made all the time in the design, construction, and materials of motor-vehicles, this lack of diminution in percentages tends to show that with larger ownership there is more carelessness and neglect. The analysis clearly indicates the more vulnerable parts of a car.

The commonest cause of breakdown was ignition failure, the percentage for 1928 being 22.7, which is the same figure as that of 1925. Lack of general knowledge of the ignition is no doubt largely answerable for the comparatively high percentage. The next biggest item is axle shafts. This probably is due to overspeeding on bad roads and to bad braking. Accidents account for 13.5 per cent of the total, and this is a slight decline from the two previous years. Cylinders and pistons show an increasing percentage.

There is little doubt that breakdowns could be reduced in number were drivers generally more considerate. The figures for the last four years are given in the accompanying table.—London *Times*.

	1925	1926	1927	1928
Power Unit				
Ignition	22.7	22.5	21	22.7
Carburetion	3.0	2.5	2.6	2.6
Engine				
Cylinders and pistons	6.9	8.0	10.2	10.5
Valve mechanism, camshaft, lay shaft, secondary and timing gear	1.0	0.9	0.7	0.4
Valves	0.5	0.9	1.4	1.4
Lubrication	3.0	2.3	2.7	2.5
Water circulation	1.3	1.7	1.1	2.2
Crankshaft	0.7	0.5	0.5	0.5
Not stated	7.1	6.6	6.4	5.8
Starting	0.4	0.6	0.9	1.0
Transmission and Brakes				
Clutch	4.0	4.4	4.9	5.1
Gearbox	3.6	2.8	3.2	2.6
Couplings, universal-joints and and propeller-shafts	5	4.6	4.9	4.1
Brakes	0.4	0.3	0.2	0.1
Rear Axle				
Axle shafts	12.4	12.6	13.6	3.8
Differential	1.3	1.2	1.4	0.7
Bevels and worms	1.1	1.2	0.7	1.0
Front Axle and Steering	4.1	4.3	3.1	3.3
Road Wheels and Suspension	6.1	5.9	4.1	4.2
Lighting Failures	2.3	2.1	2.2	2.0
Accidents	13.1	14.1	14.2	13.5
	100.0	100.0	100.0	100.0

World Engineering Congress

By Maurice Holland[1]

Semi-Annual Meeting Address

ENGINEERS from every corner of the earth will meet at Tokyo, Japan, when the first World Engineering Congress opens on Oct. 29 in the capital of the Empire. Every branch of engineering will be represented, and the elaborate program includes the presentation and discussion of papers, visits to factories and laboratories, and inspection tours through various parts of Japan.

The plan of this Congress originated when, about four years ago, Dr. Kamo, president of the Mechanical Engineering Society of Japan, visited America and called upon Herbert Hoover, then Secretary of Commerce, to point out to him the timeliness of holding such an event in Japan. Two years later Baron Shiba, the first official representative of the Congress, came to this Country and a preliminary American committee was formed, with Mr. Hoover as honorary chairman and Dr. Elmer A. Sperry as chairman.

It is expected that the World Engineering Congress will prove a highly important event, by bringing into closer contact the engineers of the two principal nations that dominate the Pacific. It is not generally known in America that the membership of the Mechanical Engineering Society of Japan includes 30,000 engineers, nor is the remarkable engineering progress made during the past few years by that Far Eastern nation a matter of common knowledge.

Japan is working intensively upon a road-building program that had its inception following the earthquake of 1923. The reconstruction of Tokyo and Yokohama, after that disaster, provided for a vast increase of modern city streets, so that there are today more than 250 miles of new streets within Tokyo's city limits. These cover nearly 28 per cent of the city's area, as against 11 per cent before the earthquake. Four new national highways, radiating out of Tokyo, are under construction. The most important of these is the highway connecting the capital with Yokohama. This is 48 ft. wide, built on a concrete or macadam base and paved with asphalt. Naturally, better roads mean increased automotive transportation.

Japan's Industrial-Research Standing

Japan imports more than 10,000 automobiles yearly, and each year the number and aggregate value of these are increasing. While automobile imports in 1927 increased 100 per cent over 1926, the growth in truck and motorcoach imports was 300 per cent. Two American motor-car manufacturers have established factories in the Far East. Another way of expressing the rapid modernization of Japan, particularly in the matter of transportation, is to state the fact that the number of jinrikshas used in Tokyo streets dropped from 18,000 in 1918 to 2000 in 1928, while the number of taxicabs now almost equals that of these ancient-type conveyances.

Since the vast reconstruction program undertaken by Japan involves every type of engineering work, it is not astonishing that research is coming in for its proper portion of this enterprise. The Japanese are aptly described as "the Germans of the East," and the phrase is true particularly in the matter of research. The nation supports, in its basic industries, 93 research laboratories manned with high-class personnel and provided with most modern equipment. In my opinion, Japan today occupies fourth place among the nations of the world in the organization of industrial research. With that foundation, we may be sure that her industries have something of interest to all American engineers, particularly to automotive engineers.

The American Committee of the World Engineering Congress includes such prominent members of the S.A.E. as C. F. Kettering, who is one of the vice-chairmen of the Committee; Past-Presidents Howard E. Coffin and John H. Hunt; and C. B. Veal.

Program of the Congress

The program of the Congress provides for the first week to be devoted to the purely technical sessions that will bring the opportunity for an exchange of ideas among engineers from all parts of the world. The second week will be given over to inspection trips in and around Tokyo, while during the last two weeks the American engineers will be guests of the Ko-Buc-Ki, the Federated Engineering Societies of Japan, representing 17 specific engineering societies, on an extensive journey through the principal Japanese factories in Japan, Korea and southern Manchuria.

The World Engineering Congress is sponsored by the Imperial Japanese Government. Passes on all railroads and steamship lines are usually accorded to any foreign delegate attending an international congress in Japan. As it is felt certain that most of the American engineers attending the Congress will be accompanied by their wives, Mrs. George D. Barron has agreed to undertake the formation of a ladies auxiliary to organize the program of the lady members of the party in Japan. Japanese ladies, too, have worked out a comprehensive program for the entertainment of their visitors.

The American engineers will sail from San Francisco on the President Harding, the official steamer of the Dollar Steamship Line, on Oct. 11. It is estimated that the trip will occupy about two months, and its cost should be approximately $1,500 per individual. Many delegates from European countries will join the Americans at the Pacific seaboard, and the steamer will be reserved entirely for the party bound for the Congress.

[1] M.S.A.E.—Executive secretary, American Committee, World Engineering Congress; director, National Research Council, New York City.

Automotive Research

Wheel-Alignment Investigation

Subcommittee Progress Report on Methods Followed and Indications of Data Gathered

A YEAR ago the Research Committee of the Society appointed a Sub-committee to get in touch with tire makers and car manufacturers to obtain available information on the fundamentals affecting wheel alignment. A survey of the field showed a dearth of experimental data and a considerable difference of opinion on the causes, extent and effects of misalignment. Hence the Committee has undertaken to secure manufacturers' specifications on camber, caster, king-pin inclination, and turning-radius; to check these specifications on the cars as they are purchased; and to follow up the variation in these factors with mileage, in the hope of determining the effect of wheel alignment on steering, road control, and tire wear. Early in the undertaking it was found necessary to investigate the various types of wheel-alignment measuring device with the idea of determining which instrument would best serve the purpose of this project.

Cooperation was offered by the General Motors Proving Ground in securing data on new cars as purchased from the manufacturers and in recording the change in alignment through service on the road.

In starting to collect these data, various manufacturers' instruments were tried out in an attempt to get a device to read accurately with the minimum trouble of set-up. The nearest-to-level place was selected on a concrete floor, and all readings were taken at this place. The difficulty immediately encountered was that readings taken on a car could not be checked within what was considered reasonable limits. Therefore, a large level surface-plate on which to mount the car was built up of steel bars about 9 in. apart embedded in concrete. These bars were filed down after being placed so that no point is more than 1/64 in. from level.

Methods of Taking Readings

The car is first checked over carefully to make sure that all conditions are normal. This includes filling the gasoline tank and radiator, spare tire and rim in place, tires inflated to recommended pressures, and spindle nuts taken up. The car is then placed on the large surface-plate, and each front wheel is mounted on two steel plates with a ball thrust-bearing between them. The rear wheels are mounted on wood blocks of a height corresponding to the steel plates under the front wheels. A vertical sliding trunnion is fastened to the center of the front axle to prevent sideward motion of the car when the wheels are turned. A dial indicator is mounted on to the end of the spindle in such a way that it will contact with a tilting table which rests on the surface-plate. The front wheels are then turned back and forth and the tilting table adjusted until all readings of the dial indicator are within 0.005 in. of each other. With the table so adjusted, readings can be made directly in degrees of the caster and king-pin angles.

Before taking readings of toe-in or camber, the car is placed directly on the large surface-plate. For reading toe-in, a U-shaped gage is used which rests on the surface-plate and projects up to approximately the center line of the wheel. The gage is first placed under the car and the uprights placed against the tire and set at zero reading with the wheels pushed apart in front. The car is then rolled forward, the gage placed in front of the car with the uprights at the same places on the tires, and the wheels again pushed apart in front and the reading taken.

An instrument which reads directly in degrees was made for reading camber. This instrument is mounted on a pedestal which rests on the surface-plate and has two projecting arms which contact with the wheel felloe in a vertical plane. The instrument is so placed that the upper stationary arm contacts with the felloe direct. The lower arm moves out and in, and with it a swinging pointer which indicates the camber in degrees when the arm comes in contact with the felloe. Two readings are taken with the wheel in 180-deg. positions, and a mean is taken so as to provide for any possible distortion.

Suitable Instruments Needed

Some attempt has been made to measure turning radius. The only instrument used thus far has been one that would give a reading when the outside wheel is in a 20-deg. position. As it was thought desirable to get more complete information when investigating the turning radius, readings with this instrument have not been taken.

Consideration has been given to getting information on tire wear at the Proving Ground, but thus far nothing definite has been done on account of lack of suitable, convenient means for recording the wear. A special tire-template will be tried out.

The method of taking readings as outlined is, so far as we know, different from that recommended by any of the manufacturers of wheel-aligning equipment. However, few such manufacturers agree on the proper method of taking such data, which leaves no standard to follow. While passing through the preliminary stage, it was thought advisable that all readings be taken with the car in as nearly as possible its normal operating position.

Engineering specifications were obtained from almost all of the car manufacturers. Readings are taken of the car as purchased, which should check the manufacturer's specifications. Additional readings are taken every 5000 miles. All of these data are recorded for one car on a data sheet so that the complete record of one car can be read.

Indications from Data

A study of the data collected up to this time clearly indicates (a) that few companies attempt to check the front-wheel alignment before the cars leave the factory, (b) that the car does not hold its original setting for any length of time on the road. Some thought has been given to attempting to measure spring sag, axle distortion, and wear of parts, in an attempt to tie down the reasons for these variable readings.

No definite program on tire wear as affected by various front-wheel adjustments has been outlined up to this time. The cooperation of several of the tire companies has been promised.

While this report is not at all complete, the Committee thought it desirable to present the information at hand in the hope that it would bring out some discussion and criticism of the methods used.

J. M. Nickelsen,
Chairman.

Transportation Engineering

Air-Cleaners and Oil-Filters

Pacific-Coast Usage and Operators' Opinions of Effect on Maintenance

A STUDY of the effect on motor-vehicle maintenance resulting from the use of air-cleaners and oil-filters was undertaken by Subcommittee No. 2 of the 1928 Operation and Maintenance Committee, and this was reported upon by E. C. Wood, Chairman of the Subcommittee, at the Transportation Meeting held in Newark, N. J., Oct. 18, 1928. The report follows:

Report of Subcommittee No. 2

Undoubtedly the air-cleaner has become an important factor in many sections of the Country in lowering the cost of vehicle maintenance. The efficiency and practicability of the various makes and types of air-cleaner are affected by geographical and operating conditions. We are leaving the technical study of their efficiency to engineers who have the required laboratories and apparatus. In the Pacific Coast section their efficiency is such that they repay the expenditures they involve.

Our object is to present the problems of the large-scale and the small-scale fleet-operator, the results obtained from centrally operated fleets and from isolated units, and to explain conditions that prevail in different sections, by presenting abstracts from various replies received to questionnaires, as follows:

Question.—What type of air-cleaner do you consider the most efficient?

Answer (1).—The moving centrifugal self-cleaning type is the most efficient and most practical from the operator's viewpoint. The type that must be removed or dismantled for cleaning has proved to be very efficient, but the individuals with whom it is necessary for us to deal in the isolated districts allow the filter to become clogged, thus starving the engine for air. Operators then remove the tube to the carbureter and run without the air-cleaner functioning. This is true of all types of felt cleaner that have to be dismantled for cleaning.

Answer (2).—Considering all the conditions under which an air-cleaner is used, we believe that the centrifugal type is the most efficient.

Question.—What results have you noted in air restriction and fuel consumption?

Answer.—The mechanical, rotating, centrifugal, self-cleaning type in no way changes the airflow or increases the fuel consumption. I have completed a series of dynamometer tests with a number of air-cleaners and have removed 98 per cent of silica sand by actual weight from the airstream in 8 or 10 runs, the engine being operated to get the variable air-pressure that the carbureter air-intake requires, as follows: 39 sec. idling; 49 sec. building up; 2 min., 9 sec. running at peak load; 49 sec. returning to idling position, and repeat. This cycle was secured by an electrically driven mechanical device directly connected to the throttle of the engine in the dynamometer frame. Since these tests, we have standardized on that type of air-cleaner.

Question.—At what periods do you recondition air-cleaners?

Answer.—We have not found it necessary to do any reconditioning on the centrifugal type. We have found it necessary to replace the cleaning element on another type after short periods of operation in very dusty sections, but in sections where dust is not so prevalent, the service given by this type has been satisfactory, although it has to be inspected at short periods to make sure that there is no interference with the air supply to the carbureter.

Question.—To what extent has your overhaul period been extended by the use of air-cleaners?

Answer (1).—The period has been extended more by the air-cleaner than by any other accessory. It gives longer life to the cylinders, piston-rings, pistons, valve-stems and guides. We believe the life of the engine has been extended approximately 20 per cent by the air-cleaner.

Answer (2).—Our overhaul period has been extended 36 per cent.

Answer (3).—In the Texas oil-fields the overhaul period has been increased 50 per cent.

Answer (4).—We have increased the life of the cylinder-block, piston and piston-rings as much as 700 and 800 per cent. The average life of the standard-model vehicles in certain parts of the Texas oil-fields was 60 days; the cylinders wore out-of-round during that period from 0.040 to 0.060 in. and became tapered. We now secure 14 to 16 months' service before the cylinders get out-of-round from 0.008 to 0.012 in.

Question.—What percentage of air contamination is removed by the air-cleaner?

Answer (1).—Air-cleaners used by our company remove as much as 98 per cent under average conditions in our locality.

Answer (2).—We estimate that about 60 per cent of the abrasive in the air entering the carbureter is removed, as determined from two different types. Cleaners of other types probably remove a greater proportion, but we feel that the removal of the most harmful abrasives is included in the 60 per cent.

Answer (3).—In our locality, air entering the carbureter is 85 per cent freer from silica or sand dust when an air-cleaner is used.

Question.—What difficulties have you experienced with air-cleaners?

Answer.—The general difficulty is that the air-cleaner becomes clogged, thus restricting the air passage to the carbureter.

Question.—What saving in engine maintenance do you credit to the air-cleaner?

Answer.—One large-scale fleet-operator says that the engine-maintenance cost is reduced about 20 per cent. Others report this cost to have been reduced from 25 to 46 per cent.

Question.—What suggestions have you to increase air-cleaner operations?

Answer (1).—Air-cleaners can be used satisfactorily only by a large operating company after a survey has been made of actual geographical, geological and topographical conditions. Air-cleaners that would prove satisfactory in one section may be complete failures in another part of the Country. The felt-type cleaner will work very satisfactorily in the arid desert regions, but will fail in the humid regious because felt absorbs moisture from the atmosphere, and the dust forms a thin cake on it. This has been known to starve the engine to the point of stalling with new air-cleaners that had been in service only two or three days.

Answer (2).—We believe that the air-cleaner should be located on all equipment so that it will not be in contact with the greatest quantity of road dust. Mounting at the carbureter intake we believe to be satisfactory, provided the car or truck is equipped with an under-pan.

Observations of Oil-Filters

Of the various methods of maintaining the purity and cleanliness of crankcase oil, our observations were confined to the oil-filter and its functions in operation. The oil-filter has become a very practical means of partly eliminating the many variables and compounds that affect engine lubrication. The types observed consist chiefly, in general, of a gauze or cloth pad placed in such a way as to filter out the solid impurities as the oil is pumped through the lubricating system.

The important feature of an oil-filter for efficient and economical functioning is that it shall be accessible and readily dismantled, as a thorough cleaning is essential after a period the length of which is governed by the condition of the engine and the operating conditions. Otherwise, the filtering mediums become clogged with carbon and other impurities to such an extent that the oil is bypassed and the filter becomes inoperative. These various oil-filters were installed, as specified by their respective manufacturers, on various passenger-cars and trucks which were op-

erated on the highways within a field radius of approximately 100 miles from San Francisco.

In some of the filters that we were unable to dismantle and clean, we found that the oil was bypassing long before the efficient operating period, as specified by the manufacturer, had passed. Other failures that developed under road conditions were due to decomposition of the filter cloth at a point near the intake connections. These ruptures probably were caused by chemical action, hydraulic pressure and temperature, any one or a combination of the three. The filter operation on the heavy trucks was satisfactory, as the filters were of a type that could be cleaned at each period of oil change. The reconditioning cost was nominal and gave assurance of efficient operation. With the enclosed types of filter on the passenger-car fleet, the contamination of new oil and the operating conditions gave variables particular to each vehicle, according to the design of its lubricating system and the factors that govern its efficiency.

The general tendency is to install filters that have an area and capacity that are not proportionate to the quantity of oil contained in the crankcase, the pressure and capacity of the pump, and the volume of oil passed through the filter in proportion to the engine speed.

Analysis made was of the filters selected from a fleet of 24 passenger-vehicles on test, chosen because they maintained the best average operating factors. There were six filter failures in this test fleet. The average oil-change period of the units was 2000 miles, and the filters were taken off as specified by the manufacturers.

Oil-Filter Questionnaire

The following questions were sent to various fleet operators to obtain operating factors and the variables that would present an average operating condition in the San Francisco district. The replies contain so much valuable information of the varied operating conditions that it is impossible to give it in detail, so they are summarized, as follows:

Question.—What make and type of oil-filter do you consider most efficient?

The general opinion confines approval to three popular makes and specifies the various operating conditions, such as climatic, geological and topographical.

Question.—What make and type of oil-filter requires the least attention?

Replies specified the heavy-duty type, which can be dismantled and easily reconditioned.

Question.—What trouble have you had with any type of oil-filter?

Some of the major troubles were: The bursting of containers from hydraulic pressure, leakage at element tanks and pipe connections, and failure of the driver to recondition the filter at the proper time.

Question.—What percentage of saving in engine maintenance do you credit to the oil-filter?

The opinion is that the life of some engines has been increased considerably, especially where the oil was changed after approximately every 2000 miles of operation. Where the oil was not changed, no increase in engine life was noticeable. In some replies, savings of 12 to 15 per cent were estimated theoretically; and up to approximately 20 per cent where the oil was changed at 2000-mile intervals. In one case the percentage was given as 50 per cent, compared with previous observations. The average cylinder-wear in heavy-truck engines was reported as 0.001 in. with filters and 0.004 to 0.006 in. without them.

Question.—What percentage of oil cost have oil-filters saved?

From 32 to 60 per cent was reported, according to variables of operation.

Question.—What comparative cost-data have you on bearing lubrication with and without oil-filter operation?

No data are available at present.

Question.—At what mileage or time do you recondition the oil-filters?

The change period varies from 10,000 to 20,000 miles, according to the make and type of oil-filter used. Difficulty is experienced in getting the various operators in isolated sections to change the cartridge or element at the proper mileage interval. The general opinion is that a standardization of oil-filters that can be dismantled and cleaned at various periods will best meet the operating conditions.

Question.—How do you determine the condition of the oil?

Methods in use for this determination vary from laboratory analyses and laboratory runs to measuring crankcase-oil dilution and deposits of silica, metallic particles and their oxides, and acidity, viscosity, flash and fire tests as practised by some of the larger companies, to the mere inspection of samples from the crankcase.

Question.—What effect have you experienced from various grades of oil passing through the oil-filter mediums?

In some instances the retardation of oil-flow in gallons per hour was governed by the temperature of the oils entering the filter mediums and the bypassing of oil until the filter was warm.

Question.—What percentage of oil do you believe the oil-filter reclaims?

As to sediment, the three types of filter are efficient for a time, and efficient filtration is assumed to increase the mileage of any oil from 70 to 75 per cent.

Question.—What effects have you noted from water in the filter?

It has been found in the northern portion of California that virtually all models freeze and cause cartridge rupture, and in other localities emulsions are formed that lower the efficiency of the filtering element.

Question.—What were the causes of oil-filter failures?

The generally reported causes are: Lines becoming clogged, rupture of cartridges, leaks, and neglect.

Question.—Has the oil-filter extended your overhaul period?

This question has many affirmative and many doubtful answers. It is not feasible to give a general opinion, in view of the various types of vehicle and filter and the varied operating fields and other conditions.

E. C. Wood,
Chairman.

Suggestion Box Efficacious

ANYONE in our organization can make suggestions for improvements. The form provided is in two sections, each of which bears the same number, and the person who makes a suggestion does not sign his name. The numbering eliminates partiality when the suggestions are analyzed twice monthly by the executives of the company. If the suggestion is adopted, the person who made it is called to the president's office and is presented with a check representing the cash value of 10 per cent of the annual saving which his suggestion has made possible. Numerous savings of from $1,000 to $2,000 per year have been accomplished as a result of suggestions made in this manner, and the practice promotes the good-will of the employees.—[Bernard Wahle, superintendent of operations for the Motor Transport Management Co., Chicago, in discussion presented at a Chicago Section meeting.]

Motorcoach Maintenance

THE preventive-maintenance system used by The Cleveland Railway Co. is described in the paper on Motorcoach Maintenance, by Leonard Rose, assistant superintendent of the company's motorcoach department in charge of maintenance. The paper is printed in full in this issue, together with the discussion, beginning on p. 405. Details of the company's practices are given, an interesting feature being the presentation of the record forms and a description of how they are used.

Store-Door Delivery

MOVING freight from a railroad terminal to the consignee's premises, or from these premises to the railroad terminal, is termed "store-door delivery." A comprehensive paper on Canadian methods in this regard, by R. A. C. Henry, of the Canadian National Railways, is printed in this issue, beginning on p. 425, together with the discussion which followed its presentation.

Production Engineering

Buyers' Tests for Brake-Lining[1]

Physical and Chemical Tests Suggested to Check Identity of Material with Sample

BRAKE-LINING is a peculiar material. The manufacturer usually knows what is put into it but does not know what it is like when it is finished. All users of brake-lining know that it is impossible to predict when a serious epidemic of trouble will break out because of unheralded changes in quality. Each manufacturer of brake-lining seriously believes and affirms that his product is uniform in quality and identical to the approved sample, because he exercises careful control over all elements in its manufacture. The asbestos is carefully selected; but, as Mother Nature mixed all kinds of asbestos together and added a little dirt, many admit that they start under a handicap. The asbestos cloth, yarn, paper, mash or what not, is carefully inspected. The frictioning and folding, or the weaving and impregnating, or the mixing and molding, are carefully watched. The curing or drying is carefuly controlled. The product is faithfully emblazoned with a name, carefully packed, and shipped to the trusting purchaser.

Now and then a piece of this carefully manufactured material is put on a brake-lining testing-machine or in some other intricate device and some important data obtained which, I believe, is carefully filed so that the next batch of lining will pass the test.

Every automobile manufacturer inspects each part that goes into his product, both as to material and finished dimensions; but, when all these inspected pieces are assembled into an engine or into a completed car, the assembly or finished product is carefully examined to see if it is the kind of product desired. The engine will probably be run on a dynamometer. This test not only shows that the engine will run, but that it develops the power expected. The completed car will be operated on rolls or on the road for a few miles to see whether or not it meets the standard of expectation described by the salesman to the purchaser.

Necessity of Final Inspection

In general, in the manufacture of automobiles, not only is each part and each assembly inspected, *the final product is inspected.* This serves as an over-all check on every step in the manufacture and the interrelations of each part with the others. Sometimes this final inspection reveals that the brake-lining is not acting the same as it was yesterday; and, when the brake-lining representative is questioned on this point, he explains how carefully the product is made so that it cannot be different from one day to the next. In my opinion, he is often serious in this belief; but, when the facts of the case are finally brought to light, the lining furnished on two different days is definitely established to be different. The brake-lining manufacturer is very sorry, something must have slipped; he is not able to say just what. Sometimes one of his competitors gets the business, only to lose it again, perhaps, for the same reason. These peculiar and often mysterious brake-lining illnesses cause losses on the part of everyone concerned.

During or after one of these experiences, the brake-lining manufacturer will promise to make the lining just as the car manufacturer desires; but how can the car manufacturer tell the brake-lining manufacturer how to make his product? The extent of the car-manufacturer's information is that, once upon a time, he had received some brake-lining which gave no trouble. He has learned from bitter experience that brake-lining testing-machines and accelerated brake-lining tests on cars are not reliable. He knows that he must find a sample of lining which can be driven 15,000 to 20,000 miles under usual conditions without grab, squeal, hard pedal, rapid wear, or any other difficulty. When he has found such a sample, his problem is how to be sure he can obtain enough more like it to meet his production requirements.

Tests for Identity of Material

Another way to state this problem is to ask what practical tests of a "go" and "not go" nature can be used to check the incoming shipments for their identity with the tested sample. As identity of material is desired, and no satisfactory accelerated performance-test has been devised, simple physical and chemical tests should be used, the results of which can be given tolerance limits and not be subject to the personal judgment of the tester.

Several properties which can serve as identity tests are: surface coefficient of friction; change in weight and thickness after being soaked in water, oil or a solvent; loss of weight and character of volatiles removed when the sample is heated to a certain temperature; hardness; stiffness; tensile strength; stretch; density; thickness; width and yarn count. Arbitrary tests that can be made in a very short time can be established for one or more of these properties, with numerical values for tolerance limits.

When this method of check is suggested, the most natural question is: "What have these properties to do with the actual performance of a brake-lining on a car; why not adopt a test that is more like actual use?" The answer is that, after about ten years' endeavor by many people, no such test has been forthcoming. Meanwhile, brake-lining is being manufactured with no check on its uniformity, awaiting that Utopian day when the much sought ideal test is developed.

The suggestion I wish to make is that, when a roll of brake-lining is found to be satisfactory in actual use on a car, we identify that piece by means of simple "go" and "not go" tests selected, with the help of the manufacturers, so that they bear as directly as possible on the type of lining and its manufacture. The identifying tests will not be the same for all linings, because they should be as few as possible and point toward variations in particular manufacturing processes rather than performance in use.

This suggestion has been criticized as being theoretical. Possibly it is; but, if one piece of material is found to be satisfactory, it is good policy to insist on getting material like the good piece.

Such tests would be valueless for comparing linings of two different kinds. They are to establish the identity of two materials supposedly alike, the master sample and the daily product. When a brake-lining manufacturer begins to use such tests, he will find a marked variation in his product in spite of his supposed care in manufacture.

An Automatic Testing-Machine

The question of the time and cost of such tests will always arise. The answer to this cannot be definite, but I

[1] Paper read at the Annual Meeting by William S. James, M.S.A.E., research engineer, Studebaker Corp. of America, South Bend, Ind.

know of one case in which such testing has been carried out for more than six months with less time and cost than was expected and with gratifying results as to uniformity of product and inspiration to the producer of the brake-lining.

To demonstrate more concretely the practicability of this method, a relatively simple machine has been designed and constructed which tests every foot of a roll of brake-lining, at the rate of about 30 ft. per min., for surface coefficient of friction, stretch, thickness, width, and bleeding when heated. The indications of the machine are automatic, and the machine is stopped when definite limits are exceeded.

The machine includes a driving mechanism that draws the lining from the roll through a heating element and under a loaded friction-shoe. The coefficient of friction is measured by horizontal springs at the shoe, and the stretch is measured by counters which roll on the lining before and after it has passed under the friction shoe. We made the first tentative design of the machine, and it has been constructed by the Bendix Brake Corp.

In brief, it is my conviction that one of the greatest obstacles to better and more reliable braking-systems is a complete failure of the brake-lining manufacturers to produce a lining which they *know* to be uniform. A mediocre lining made uniformly is of greater value than a wonderful lining that is not the same from day to day. Molded linings are offered as more uniform because the method of manufacture is *believed* to be more controllable. It will be a great advance when manufacturers of brake-lining, molded or of any other kind, can *prove* that their *product*, not their *process*, is uniform.

Deep-Hardening with Cyanide Salts

Modified Bath of Sodium Cyanide Used in Rapid Case-Hardening Process

SALT-BATH hardening has hitherto been regarded as a process suitable only for small work on which a thin case is required. By the addition of various ingredients to sodium cyanide, however, the Deutsche Gold und Silber Scheideanstalt, of Frankfort-on-Main, has evolved a flux by means of which a satisfactory case up to 1 mm. (0.04 in.) deep can be obtained.

This salt is known as the Durferrit hardening flux, and has been placed on the market in England. The process has now been in use for sufficient time to enable comparative data to be obtained regarding the results, and the agents recently arranged a demonstration at the works of D. Gestetner, Ltd., at which the claims made for the depth of case, time of carburizing and economy were verified.

A hooded furnace of special construction is used; and the initial charge consists of a quantity of tempering salt, to which is added, after melting, three times the weight of Durferrit hardening flux. The temperature is then raised to about 950 deg. cent. (1742 deg. fahr.) for ordinary steels, and the work is immersed for a period depending on the depth of case required. It will be noted that a high temperature is used to accelerate the absorption of carbon; but it is claimed that the structure of the steel is not impaired, owing to the fact that heating is uniform and occupies a relatively short period. Samples of work treated at this temperature certainly showed no signs of overheating, a fine-grained fracture being obtained, while if desired the core can be refined by a further immersion in the bath for a short period, giving a still finer grain.

Flexibility and Speed Secured

The exact temperature employed should, of course, be varied to suit the material being treated; and, once the required temperature has been found for any given class of steel, it should be accurately maintained by using a pyrometer. Widely different components can then be treated in the same bath on a time basis, the length of time being found for each part and depth of case, so that a simple chart can be prepared and hung up in the hardening shop.

Regarding the actual time required, a case 0.02 in. in depth can be obtained under average conditions in ½ hr., while immersion for 2 hr. in the bath will give a case 0.04 in. deep. The refining or tempering process may, of course, be carried out by a second immersion in the same bath for a much shorter period of approximately 10 min.; but for work on a routine basis it would be preferable to use a second furnace charged with tempering salt and a small quantity of Durferrit flux and maintained at a lower temperature, say 760 deg. cent. (1400 deg. fahr.). Water, brine or oil may be used for quenching, according to the properties required.

Preheater Serves Double Purpose

When taken from the quenching bath, steel parts have a clean silver-gray surface, and after washing in hot water can be sent directly to the plating or finishing department. Absence of distortion is a claim made for the process.

It is important that there be no moisture on the work when it enters the salt bath, and the supply of salt itself must be kept dry. For this reason, and for economy in heating, a preheater may be attached to the furnace to utilize the waste gases and at the same time bring the work to an initial temperature of about 400 deg. cent. (752 deg. fahr.). The furnace itself may be gas or oil fired, and is fitted with a cast-steel or wrought-iron pot, ranging in size from 7 in. in diameter by 12 in. deep to 19 in. in diameter by 19 in. deep. Two burners are arranged tangentially near the base of the furnace, the gases being conducted through spiral flues around the pot to an outlet which discharges into the preheater.

In the case of a furnace 8½ in. in diameter by 17½ in. deep, the maximum gas consumption is approximately 550 cu. ft. per hr.; but once the required temperature has been reached it can be maintained with a much lower consumption, depending on the amount of work passed through the bath. Gas at mains pressure is used with air at a pressure of 3 to 5 lb. per sq. in., supplied from a simple form of blower. In the larger furnaces, which have a working capacity up to 350 lb., the gas consumption is proportionately less.

The salts can be used over and over, the amount actually consumed being approximately 2 per cent of the weight of the work. The figures given herewith for securing a 0.04-in. case apply to transmission gears made from case-hardening steel of 0.13 to 0.15 per cent carbon. The first quenching is in water, and the quenching after reheating is in brine.—*The Automobile Engineer.*

Production Papers in This Issue

TWO PAPERS and one discussion of particular interest to production men will be found in this issue of THE JOURNAL. N. H. Preble's paper on Material Handling in the Pontiac Assembly Plant, beginning on p. 417, shows very clearly the general arrangement of the plant. By means of floor plans and photographs, the whole assembly process can be followed.

Another paper of interest, entitled Chromium-Plating Progress, beginning on p. 397, carries with it the discussion presented at the Annual Meeting. The authors, W. M. Phillips and M. F. Macaulay, discuss constant temperature, current density, methods of inspecting chromium-plate, and chromium-plating to reduce wear.

Discussion of John Younger's paper, on How the Ford Company Gets Low Production Costs, presented at the Production Meeting and printed in THE JOURNAL for December, 1928, will be found on p. 401.

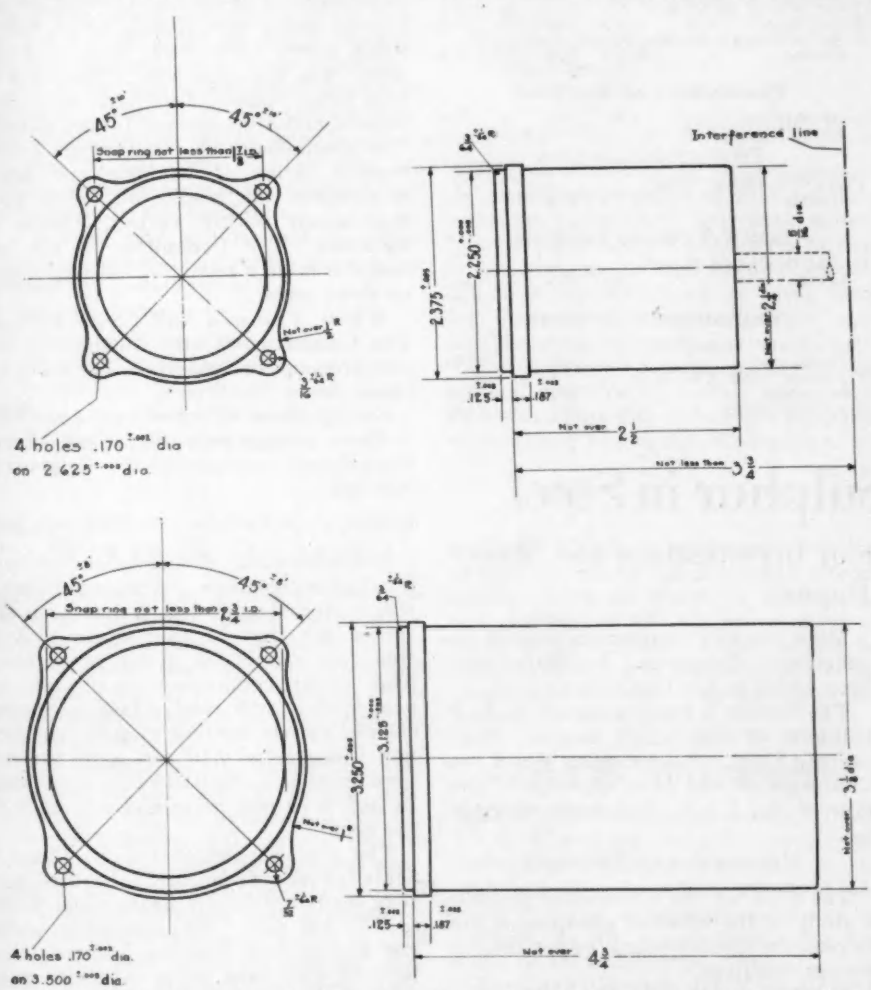
Standardization Activities

Aeronautic Instruments

Subdivision Recommends Instrument-Mounting Dimensions and Thermometer-Bulb Specifications

SPECIFICATIONS covering mounting dimensions and over-all case dimensions for aeronautic instruments were drawn up by the Subdivision on Aeronautic Instruments at the meeting held in the offices of the Society in New York City on March 21. In these specifications two sizes of case are provided, the smaller one for thermometers, pressure gages, ammeters and voltmeters, and the larger one for tachometers, air-speed indicators, turn and bank indicators, clocks, and the like.

Except in over-all depths of the cases and that limits have been added to the dimensions, the specifications are in accord with the dimensions approved by the Army and Navy Standards Conference in Philadelphia on Feb. 11 and 12. The specifications presented herewith show one maximum depth for all instruments fitting the larger case and a similar dimension for instruments for the smaller case. These maximum dimensions are sufficiently large for the installation of any present instruments.



These specifications give the basic mounting and case dimensions for aircraft instruments in two sizes. Instruments having 1⅞-in. (nominal) dial size are thermometers, pressure gages, ammeter and voltmeter; all other instruments use the 2¾-in. (nominal) dial size. On the drawing of the 1⅞-in. instrument, an interference line has been indicated to provide sufficient clearance for connection tubing on thermometers and pressure gages.

In the drawing of the 1⅞-in. case an interference line has been provided, with a maximum dimension to this line from the front of the case to assure clearance for the ammeter and voltmeter terminals and the necessary attaching and bending of pressure lines.

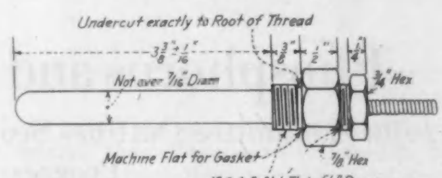
The proposed specification follows:

INSTRUMENT MOUNTINGS AND CASES
(BASIC DIMENSIONS)
(Proposed S.A.E Standard)

It is the intention of the Subdivision ultimately to supersede these specifications with a specification for each of the instruments concerned, so that outlets and attachments can be shown as well as the dimensions, threads, and so forth, necessary for the attaching of tubing and flexible cables.

Besides the proposed instrument standards, a specification showing thermometer-bulb dimensions was approved, as it was felt advisable to supply information on this equipment so that sufficient clearance might be provided within the various engines for the installation of such bulbs. The proposed specification is as follows:

THERMOMETER BULBS
(S.A.E. Standard)



The foregoing specifications will be submitted to the Aircraft and Aircraft-Engine Divisions respectively for approval at meetings to be held in Detroit on April 10.

Final Approval of Standards

ALL of the reports of Divisions of the Standards Committee presented to and approved by the Standards Committee at its meeting in Detroit on Jan. 15, and subsequently by the Council and the general Business Session, were referred to the voting membership of the Society for approval by letter-ballot. The ballots were counted on Feb. 21, in accordance with the Standards Committee Regulations.

Thirteen Divisions of the Standards

Committee had submitted 27 reports, 6 of which were new specifications, 15 were for revisions of present specifications, and 6 for cancellation of obsolete specifications. Of the ballots mailed to 3086 members of the Society, 329, or 10.75 per cent, were returned. With the exception of the ballots returned following the Annual Meeting in 1927, this was the smallest return since the Annual Meeting in 1918.

The new and revised specifications approved by this letter-ballot, with the exception of the Production Standard on Plain Cylindrical Ring-Gages, are printed in the 1929 edition of the S.A.E. HANDBOOK that was mailed to the members in March. The Production Standard for Plain Cylindrical Ring-Gages was printed in the January issue of the S.A.E. JOURNAL, but final publication of the report has been held in abeyance pending completion of arrangements for this with the American Gage Design Committee. When the report is released it will be sent to only those members who have indicated their desire for the Production Standards Reports, either by correspondence or in reply to the notice published in Chronicle and Comment in the February issue of THE JOURNAL.

RESULT OF LETTER-BALLOT

(R) Revision; (C) Cancellation; (R P) Recommended Practice; (S) Standard.

		Approve	Do Not Approve	Not Voting
AERONAUTIC DIVISION				
Propeller-Hubs and Shaft-Ends	(R)	148	2	179
AGRICULTURAL POWER-EQUIPMENT DIVISION				
Tractor Power-Take-Off Speed	(R)	128	0	201
AXLE AND WHEELS DIVISION				
Front-Axle Hubs	(C)	168	2	159
ELECTRIC VEHICLE DIVISION				
Charging Plug and Receptacle	(R)	125	0	204
ELECTRICAL EQUIPMENT DIVISION				
Starting-Motor Mountings	(R)	192	2	135
Timer Distributors	(R)	191	0	138
Rubber Bushings	(R)	183	4	142
Generator Mountings	(R)	192	2	135
LIGHTING DIVISION				
Tail-Lamps	(R)	181	0	148
Signal-Lamps	(C)	176	1	152
Lamp Lenses	(R)	181	0	148
Head-Lamp Mountings	(R)	181	0	148
LUBRICANTS DIVISION				
S.A.E. Viscosity Numbers	(R)	202	10	117
MOTORBOAT DIVISION				
Marine Shaft-Couplings	(R P)	142	3	184
Marine Propeller-Shafts	(R P)	118	2	209
Marine Propeller-Hubs	(S)	117	3	209
Engine-Bed Timbers	(C)	113	0	216
MOTOR-TRUCK DIVISION				
Trailer Hitches	(C)	154	0	175
Motor-Truck Bodies	(C)	155	1	173
Motor-Truck Cabs	(C)	155	1	173
Motor-Truck Dump Bodies	(R P)	156	2	171
PASSENGER-CAR DIVISION				
Leaf Springs	(R)	182	0	147
PRODUCTION DIVISION				
Plain Cylindrical Ring-Gages	(R P)	173	0	156
SCREW-THREADS DIVISION				
Round Unslotted-Head Bolts	(S)	175	2	152
TRANSMISSION DIVISION				
Control and Gearshift Positions	(R)	193	1	135
Flywheel and Clutch Housings	(R)	194	0	135
Clutch Facings	(R)	197	0	132

Phosphorus and Sulphur in Steel

Joint Committee Outlines Scope of Investigation and Makes Progress Report

IN 1919 the Joint Committee on Investigation of the Effect of Phosphorus and Sulphur in Steel was formed by the American Society for Testing Materials, the Bureau of Standards, and the then existing United States Railroad Administration. It consisted of representatives of the following:

American Foundrymen's Association
American Railway Association, Mechanical Division
American Society for Testing Materials
Association of American Steel Manufacturers
National Research Council
Society of Automotive Engineers
Society of Naval Architects
Steel Founders' Society of America
United States Bureau of Standards
United States Navy Department
United States War Department

More recently, representatives of the American Petroleum Institute have been added to the Committee.

The Society's representative is F. P. Gilligan, of the Henry Souther Engineering Corp., who for many years was Chairman of the Iron and Steel Division of the S.A.E. Standards Committee.

PROGRAM AND REPORTS

The plan of the Committee includes a study of the effect of phosphorus and sulphur in steels coming under the following headings:

Rivet Steel (I).—The Committee completed and reported its formal conclusions on this class of steel in 1926, as published by the A.S.T.M. This group included rivet steels having a carbon range of from 0.06 to 0.12 per cent and an approximate manganese range of from 0.35 to 0.40 per cent. The conclusion of the Committee indicated that sulphur content up to 0.06 per cent in commercial rivet steel of the type studied is not detrimental, the tests having shown no systematic relation between such sulphur content and any of the physical properties determined.

Structural Steel Plates (II).—The report and conclusions on these steels, which varied in carbon from 0.16 to 0.22 per cent and in manganese content from 0.35 to 0.40 per cent, were published by the A.S.T.M. in 1924 and 1927. The conclusions on this series of tests indicated that sulphur content up to at least 0.077 per cent, which was the highest sulphur content examined, is not detrimental.

Forging Steel (III).—Eight heats of basic open-hearth forging steel were manufactured for the Committee, these having desired carbon content of 0.45 to 0.55 per cent; manganese content of 0.50 to 0.60 per cent, and phosphorus content under 0.02 per cent. The sulphur contents of the billets from the series of heats were 0.031, 0.038, 0.052, 0.061, 0.069, 0.070, 0.097 and 0.116 per cent. The material was in the form of 1-in. rolled rounds, 2-in. hammer-forged rounds, and 8-in. pressed-forged rounds. The specimens were put through a systematic order of working and heat-treatments, the results of which were maintained within certain limits of hardness. The Committee is not yet ready to issue a report of its conclusions on these tests.

Wheel, Tire and Rail Steels (IV).—The Committee is still considering the procurement of materials for tests on these steels.

Spring Steels (V) *and Castings* (VI).—These groups were discontinued from the original program by the Committee last year.

RESIDUAL SULPHUR AND PHOSPHORUS

Determination of the effect of residual phosphorus in the wrought steels comprising Groups I to V has been deferred for that of cast steels that it was felt should be given precedence. This group comprises two classes of acid open-hearth steel, Class A having desired carbon content of 0.25 per cent and Class B of 0.45 per cent, the desired sulphur being 0.045 per cent; manganese, 0.70 per cent; and silicon, 0.35 per cent.

The desired phosphorus in Class-A heats ranges from 0.025 to 0.10 per cent, and in Class-B heats from 0.025 to 0.07 per cent. The respective melting and casting practice and preparation of test bars were carefully prescribed by the Committee, and test specimens have been distributed for test but the Committee is not ready to report results.

It was suggested within the Committee that a series of tests to determine

the effect of added phosphorus in low-carbon steel is desirable. A proposed program contemplates a steel of carbon content 0.06 to 0.12 per cent and phosphorus contents of 0.025, 0.04, 0.06, 0.07 and 0.10 per cent, the phosphorus in the first heat being residual and in the other four heats, added. The material will be tested as rolled in annealed and in quenched conditions, and tension, impact, bend, shear, fatigue, and hardness tests will be made on specimens taken parallel with and normal to the direction of rolling.

In general, the automotive industry will be interested mostly in the program of this Committee relating to forging steels. The conclusions of the Committee on its several series of tests will be published by the A.S.T.M. as they are completed for release. Reports of the Committee's meetings and procedure are filed from time to time with the S.A.E., and it is anticipated that the Society, with the assistance of Mr. Gilligan, will be able later to publish a complete account of these tests, particularly on forging steel.

Aircraft Standards Meetings

During the All-American Aircraft Show in Detroit, April 6 to 13, the Society will hold a two-day technical session. The morning of Wednesday, April 10, will be devoted to an Open Standards Conference, at which all of the subjects under consideration by the Aircraft and Aircraft-Engine Divisions of the Standards Committee will be presented for informal discussion by the representatives of the entire industry.

Following the Conference, meetings of each of the Divisions will be held for the purpose of taking definite action on any of the reports that may be ready, to which no serious objection has been made in the Conference.

Proposed new and revised specifications on the following subjects are to be offered for consideration:

- Airplane Tires
- Airplane Wheels and Hubs
- Airplane Axle-Ends
- Instrument Mountings
- Aircraft Storage Batteries
- Aeronautic Spark-Plugs
- Tachometer Drives
- No. 50 Shaft-End and Propeller-Hub
- Shaft-Ends and Propeller-Hubs (Revision to include rear cone location.)
- Propeller Blade-Ends
- Propeller Clamp-Rings, Bolts and Nuts
- Magneto Flange-Mounting
- Wood Propeller-Hubs

Storage-Battery Rating Tests

THE Subdivision on Low-Temperature Characteristics of Storage Batteries has circularized to battery manufacturers and users a proposed addition to the present storage battery specification in the HANDBOOK to cover tests for determining low-temperature ratings for such batteries.

The following general paragraph on ratings and the succeeding paragraph on low-temperature rating are proposed as additions to the S.A.E. Standard on Storage Batteries, p. 190 of the 1929 edition of the HANDBOOK.

Rating Tests.—Rating tests should be made with fully charged batteries, a battery being fully charged when all cells are gassing freely and the specific gravity of the electrolyte does not rise during a period of 4 hr. while charging.

Low-Temperature Rating.—Low-temperature rating should be determined by a discharge at zero deg. fahr. at a rate of 300 amp. to 1 volt per cell. This test should follow a normal temperature discharge for 5 hr. at the 5-hr. rate of the battery (approximately 1/7 of the 20-min. rate at 80 deg. fahr.).

Battery No.	Minimum Time of 300-Amp. Discharge to 1 v. per Cell, Min.
1	1.75
2	2.50
3	3.30
4	4.50
5	3.75

Aircraft Battery-Rate Revision

SINCE the approval of the S.A.E. Standard on Aircraft Storage Batteries, pp. 13 and 14 of the 1929 edition of the HANDBOOK, it has been determined that the values shown for the minimum current for 20 amp. in the table are not sufficiently accurate and give a much higher rating to these batteries than is obtained in ordinary practice.

To make this specification conform to general practice, the following revision is being proposed to the Aircraft Division meeting to be held in the Book-Cadillac, Detroit, on April 10.

Battery No.	Minimum Current for 20 Min., Amp.
32	44
34	66
36	99

Roscoe B. Jackson

FOLLOWING an illness of two days with influenza, Roscoe B. Jackson, president and general manager of the Hudson Motor Car Co., is reported in a dispatch from France on March 20 to have passed away the previous night at Mentone, France.

Mr. Jackson was a Member of long standing in the Society, having been elected in 1912, his application bearing the serial number 107. From 1913 to 1918 he was treasurer and general manager of the Hudson Motor Car Co., and in the latter year was elected vice-president of Essex Motors as well. In 1924 he became president and general manager of the Hudson company. Mr. Jackson had been a member of the Detroit Section for a number of years.

Mr. Jackson was distinctly of a retiring nature but greatly endeared himself to those who had the privilege of knowing him. For his long intense devotion to the interests of his company and consequent progress made in the design and production of passenger cars of merit at continuingly lower prices, he deserves highly the gratitude of the industry and the public, as well as of his immediate associates.

Clyde B. Wisenburgh

NEWS of the passing away of Clyde B. Wisenburgh, who on March 7 succumbed in the Harper Hospital at Detroit to peritonitis which developed subsequent to an appendectomy, came as a shock to the many friends he had made in the automotive fields.

Born at Coshocton, Ohio, on Sept. 30, 1885, he was educated in the local grammar and high schools, and after graduation from the latter institution took a course in a business college prior to becoming connected with the then young and promising automotive industry. He entered the employment of Samson & Sessions, manufacturers of bolts and nuts, in 1901, and during the succeeding six years familiarized himself with the work of that organization in the factory and office. In 1907 he became salesman for the American Distributing Co., of Jackson, Mich., and later for the Remy Electric Co., at Anderson, Ind.

By 1917, Mr. Wisenburgh had decided to specialize in the selling of ball bearings, and in that year he became western sales manager for the Standard Steel Bearing Co., of Philadelphia, with headquarters at the Detroit branch office of that concern. He remained thus connected for almost 10 years, up to the time when he accepted a position with the Strom Ball Bearing Mfg. Co., at Detroit.

Mr. Wisenburgh was elected to membership in the Society in July, 1912, as an Associate Member.

One Billionth of an Inch

CONQUEST of space by the astronomer has its counterpart among the problems of the physicist in the laboratory. In the solution of a problem in photoelectricity, carried out in the research department of the Bell Telephone Laboratories, measurement of distances down to one billionth of an inch had to be made.

It had long been noticed that alkali metals, when in the form of thin films, were more efficient in yielding photoelectric currents than when in bulk. It was therefore desired to know more about the relation of film thickness and photoelectric response.

Of the commonly used alkali metals, which include sodium, potassium, rubidium and caesium, rubidium lends itself best to the study of thin films. It volatilizes, diffuses and deposits in vacuo at conveniently low temperatures and in short time-intervals particularly suitable for experimental purposes.

For the study of the phenomena involved, a large vacuum cell was constructed containing enough rubidium to allow a spontaneous deposit to take place on all internal surfaces until equilibrium at room temperature had been reached. This deposit, so thin that it was quite invisible, covered not only the walls but a thin square piece of black glass as well. Supporting this plate at opposite ends were platinum wires, sealed on to the front surface to make contact with the metal film. A tungsten filament, supported close behind the plate, provided radiant heat for driving off the rubidium whenever desired. The photoelectric current was collected on a large nickel anode which nearly enclosed the glass plate and filament, and an area of the cell wall was kept clean with a flame to provide a window for light to pass through to the plate.

Two series of measurements were required to find the relationship between film thickness and photoelectric response—one while the thickness was diminishing from that of a heavy, driven-on, opaque coating down to the equilibrium value (the amount tending to remain on the plate at room temperature), and the other while the rubidium was depositing on the freshly cleaned glass plate. During each process, the electrical conductivity along the surface of the glass plate was being measured. This approached the same value regardless of the direction from which the equilibrium point was approached. The question then became: "How thick is the film at its equilibrium value?"

A new method of measurement had to be adopted surpassing in fineness not only the highest-power microscope but the interferometer as well. The measurement must reach the hitherto inaccessible region between visible light and X-rays, radiations whose wave-lengths bear to each other roughly the ratio of 10,000 to 1.

It seemed likely that the thickness of the film to be measured would be as little as one atomic diameter, which for rubidium is one-half of one millionth of a millimeter. Waves of light convenient to work with are 1000 times as great as that in length. It was decided, therefore, to base the measurements of thickness on the principle that plane-polarized light, in passing through any film, experiences a rotation of its plane of polarization. The extent of the rotation is governed by the thickness of the film, the wave-length of the light and the angle of incidence. By using light of a single wave-length (the green line of the mercury-arc spectrum was chosen), and taking a set of observations at different angles of incidence with a polarization spectrometer, we were able to obtain accurate values of the thickness of the rubidium film from the known constants of the material. This was possible, not only at the equilibrium condition, but while the film was growing or diminishing. By interspersing optical and electrical measurements, we were able to find the rate at which the film increased or diminished in thickness.

A practical necessity in laboratory work thus became the occasion for creating means for measuring accurately the thickness of films so inconceivably thin as one billionth of an inch.—Bell Telephone Laboratories.

The Nitrate Field

NATURAL nitrates now supply but a quarter of the world market—three-quarters is provided for by manufactured nitrogen products. Prices of various nitrogen products have been averaging from 10 to 30 per cent below their prewar level.

For commercial supplies there are three main sources: the Chilean nitrate beds, ammonia products recovered as by-products chiefly in the coking of coal, and the various synthetic nitrogen compounds produced by direct manufacture.

About 30 years ago the advantages of the by-product over the wasteful beehive coke-oven began to be realized, and since then the world's coke-producing industry has gone over more and more completely to a by-product basis. Among the many by-products thus recovered, over 20 lb. of ammonium sulphate or its equivalent of ammonia liquor are obtained for each ton of coal coked.

By-product ammonium sulphate has secured an underlying position in the nitrate market from which it could hardly be displaced. The ammonia must be removed from the coke-oven gases before they can be utilized, and the costs of recovery are well below levels at which natural or synthetic nitrates can be produced.

It is in the direct fixation of nitrogen products that expansion has been proceeding most actively in recent years. Here the major element of cost is not nitrogen, which can be obtained cheaply and easily, but the other elements—usually hydrogen, with which it is "fixed" in usable form—the power and the costly plant and equipment required to bring about the synthesis.

Less than 5 per cent of the synthetic nitrogen is now made by the arc method; in fact, the last large plant using it is being converted to another process.

Since the war, the German synthetic-ammonia industry has progressed with great rapidity; it now produces considerably more nitrogen than does Chile and accounts for about a third of the world's entire nitrogen output.

The great growth of the nitrogen industry in Germany had its inception during the World War.

With the rapid growth of the synthetic nitrogen output and the struggle of the natural industry to maintain or increase its production, it is evident that nitrogen supplies will be plentiful and cheap.

In quantity, the fertilizer trade is by far the major user of nitrogen. For the world as a whole, agriculture probably takes at least four-fifths of the total consumption. In the United States the average application per acre cultivated is only a tenth of that in Germany. Agriculture offers a steadily but only gradually expanding outlet for nitrogen supplies.—*Commerce Monthly.*

News of Section Meetings

(*Continued from p. 372*)

Three distinctly different types of pumps are now in general use on motor fire-engines, according to Mr. Fox. These are the piston, the rotary, and the centrifugal types, each of which was described briefly. Fire engines having pumping capacities ranging upward to 1300 gal. per min. are now available. The nominal ratings, however, are qualified by requirements of the National Board of Fire Underwriters that the engines shall be capable of discharging (*a*) their nominal rated capacity at not less than 150 lb. pressure, (*b*) one-half their capacity at not less than 200 lb. pressure, and (*c*) one-third their nominal rated capacity at not less than 250 lb. pressure. The time for the rated discharge is invariably fixed at 1 min.

The effect upon the powerplant incidental to the varying relation between volume and pressure is comparable, said Mr. Fox, with the varying load on the engine of an automobile when traveling on the road. When the pumps go into action, the volume of water discharged represents a moving weight, and the pressure at which the water leaves the pumps is the equivalent of a definite vertical height through which the weight is transported. Thus the volume and pressure constitute the load on the pump.

Heavy Diesel Engines

History and Present Status of American Stationary and Marine Types Outlined at Milwaukee

DRAWING upon long experience in the industry, Charles G. Barrett, of the Nordberg Mfg. Co., addressed the Milwaukee Section on the subject, Diesel Engines in Marine and Stationary Service. The meeting was held on March 6, and followed a dinner which was served to the accompaniment of a very enjoyable musical program. Members and guests to the number of 55 sat down to dinner, and the attendance at the meeting was 75.

Chairman Cyrus L. Cole announced that the Section Nominating Committee had nominated candidates for next year's Section officers as follows: Arthur C. Wollensak, Chairman; J. R. Frantz, Vice-Chairman; Henry L. Debbink, Secretary; and W. F. Krenzke, Treasurer. Each of these men was asked to stand as he was named. Prescott C. Ritchie, Chairman of the Meetings and Papers Committee, announced that the speakers at the next meeting would be the engineers of two prominent aviation companies.

When the Diesel was first introduced, Mr. Barrett expected to see Diesel engines dotting the Country soon, he said. Development was delayed by the facts that it is a very expensive machine to build and a much more expensive machine with which to experiment. Even those manufacturers who began by taking licenses from European manufacturers had much to learn before beginning to manufacture according to their own designs.

Some Early Engines Unreliable

The first marine Diesel engine built in this Country was of 300 hp. and was installed in an oil barge operating on Long Island Sound. Employes at the factory where it was built felt that something was lacking on a Monday morning if this barge was not at the wharf for repairs. Mr. Barrett reported that, in the early days, he was trying to sell a stationary engine to a prospective customer who wanted to see one of them in operation. It was necessary to travel about 36 hr. by train to reach the Middle-Western town where such an engine was in operation. Upon arriving at the town, Mr. Barrett and his companion went first to a barber shop, where they noticed that the shop was completely fitted out with both electric lights and oil lamps. Asking the barber why he did not discard one or the other, they were told: "Well, we prefer the electric lights, but that darned Diesel engine breaks down about every half-hour, so we keep the oil lamps too."

The time is now long passed when reliable service was not obtained from Diesel engines. A few of the idle war-built boats owned by the United States Government have been revamped by replacing the steam equipment with Diesel engines. The first of this work was begun about four years ago, when 12 boats were fitted with single-screw engines of about 300 shaft-hp. each. A Government report says that, after each of these converted vessels had sailed at least 13,000 miles, the delays at sea chargeable to the equipment installed at the time of conversion amounted to 408 hr. out of 46,941 hr. at sea; less than 1 per cent. These included any troubles with the steering engine and with contaminated fuel, as well as with piston-rods and cooling systems, the last of which was responsible for most of the detentions. This is thought very creditable, considering that these engines were the first of a new design.

After giving a brief historical outline of the earlier American undertakings along this line, Mr. Barrett ascribed most of the success to the demand for submarine engines. The first submarines were powered with steam engines, which were displaced by gasoline engines; but safety demanded a less volatile fuel than gasoline.

Large Marine Engines Reversible

Present marine Diesel engines may be divided into two groups, according to whether their power is greater or less than 150 hp. Most of the engines below this size are equipped with reverse-gears, usually of the planetary type; while the larger engines, because of the difficulty of building larger reverse-gears, are designed with shifting camshafts to make the engines themselves reversible.

By far the greatest number of marine Diesel engines are used in the smaller working-craft in the various harbors, having engines of 30 to 125 hp.; but others are used on ships of all sizes up to that of the Italian-American liner Augustus, of 32,650 tons gross. This ship is 710 ft. long, somewhat larger than the Mauretania, and has four main propelling units with a total of 28,000 shaft-hp. In addition, there are three 900-hp. and nine 350-hp. auxiliary engines, bringing the total power of the Diesel engines up to 33,000 hp.

Stern-wheel river-boats are said by Mr. Barrett to offer an alluring but baffling problem for Diesel-engine designers. The present steam equipment of such boats is very inefficient, but the problem of transmitting power from the Diesel engine to a stern-wheel running at 15 to 25 r.p.m. has not been solved satisfactorily. Electric drives operate well, but the total cost is too great to meet the demand.

Stationary Service Is Varied

Stationary Diesel engines differ from marine engines chiefly in the facts that they rotate in one direction only and that the speed is not limited to 100 to 200 r.p.m. by propeller efficiency. Higher speed for stationary engines is being adopted, in spite of some prejudice on the part of users. Piston speeds for electric-generator engines have risen from 800 to 1200 ft. per min., with a proportionate decrease in weight and cost.

The principal uses of stationary Diesel engines are in municipal service, for electric power and water

pumping; in oil-line pumping, mine operation, flour mills, irrigation pumping and industrial purposes. The first cost of Diesel engines, approximately $45 per hp., is somewhat higher than for steam-engine installations, and their relative economy depends somewhat on the comparative cost of fuel and the proportion of the time the engines will be operating at an economical load.

Fuel-oil now costs only 1½ cents per gal. in Texas and 4 cents in Milwaukee. Similarly, coal is much cheaper in the coal-mining regions. These and other local considerations, such as availability of a large quantity of pure water for a steam-plant, may determine the type of power to be used.

Mr. Barrett concluded his address with a description of some of the large Diesel units built by the company he represents, and showed lantern slides of them. These included several 4000-hp. engines in use at the Panama Canal, which are said to be the largest Diesel engines that have been built in this Country. All the Nordberg engines are two-cycle and use air injection. From 1914 to 1924 they were built under license from a Belgian manufacturer. The engines built since that time are of higher speed.

In the discussion, J. B. Fisher, of the Waukesha Motor Co., reported seeing some Diesel engines of larger size in Germany, one of them being a 15,000-hp. nine-cylinder engine that is running in Hamburg.

Buoyant Aircraft Featured

Dirigibles Under Construction for Navy Described at Buffalo —Motor-Car Exhaust-Valve Problems

BUFFALO Section's biggest meeting was held on March 5, when 400 members and guests turned out to hear V. A. Jacobs tell about the new rigid airships that the Goodyear-Zeppelin Corp. is building for the United States Navy. These are the ships that Dr. Karl Arnstein described at the Aeronautic Meeting of the Society in Chicago last December, and the major features of which were summarized in the news report in the January issue of the S.A.E. JOURNAL on pp. 12 and 94. Mr. Jacobs, who is connected with the aeronautical department of the Goodyear Tire & Rubber Co., has been asked to give another paper on the subject at the Summer Meeting at Saranac Lake in June. During his address at the Buffalo meeting, motion pictures of dirigibles in flight were exhibited. Samples of materials used in the construction of the airships also were shown.

Prior to the technical session, 90 members and guests attended a dinner in the Hotel Statler at which Mr. Jacobs was the guest of honor. This was the first time the Section had had a regular dinner preceding its monthly meetings. A four-piece orchestra provided music during the dinner. Other entertainment consisting of songs and humorous stories was provided by a company of locally prominent entertainers.

EXHAUST-VALVE PROBLEMS SOLVED

How various problems in connection with engine operation have been solved by suitably modifying the shape and construction of poppet exhaust-valves is described in the paper presented at the Feb. 19 meeting of the Buffalo Section by Richard E. Bissell, chief engineer, and Gordon T. Williams, assistant metallurgist, of Thompson Products, Inc. Different types of exhaust valve are illustrated, and it is pointed out that such modifications often lead to the requirement of making special provisions for grinding-in the valves.

An interesting specimen of a modern exhaust-valve described and illustrated involves the use of a disc which is enclosed in the valve-head and is made of a special alloy of high expansion-coefficient. This type of valve-head shortens with increasing temperature, so that the stem expansion is counteracted and constant tappet clearance is maintained.

Hollow-stem valves are described, as is also the use of various materials for filling the hollow stem-portion to conduct the heat away from the head to cooler parts of the valve. Correct clearance between valve-stem and guide, tendencies in valve-guide design and lock seats are discussed by the authors of the paper, which was illustrated at the meeting with 34 slides.

POINTS IN THE DISCUSSION

In the discussion, one speaker referred to a statement in the paper regarding the use of ethyl gasoline and stated that in his firm's experience this fuel had never had any detrimental effects on engine valves. Mr. Williams replied that ethyl gasoline, in the form originally placed on the market, attacked valves and, even after its early modifications, caused the valves to pit. During 1928, however, the difficulty disappeared, although such gasoline still causes a deposit. This, however, is not harmful and ultimately cracks off, he said.

W. R. Gordon spoke of the virtues of the old-style cast-iron valves and stated that some tests at the Pierce-Arrow plant had shown them to retain their hardness up to approximately 1400 deg. fahr., while other materials proved superior at higher temperatures. The carbon contained in cast iron, he explained, gives a self-lubricating quality.

Regarding the analyses of steels used in valves, Mr. Williams declared that silchrome is now the world's standard and that high-speed steels are not used as extensively for the purpose as they were formerly. He said that silchrome steels, after continued operation, have a mirror-like surface produced by self-lubrication, while cobalt-chromium steels become rough in service.

Replying to a question by Gustaf Carvelli, of the Curtis Aeroplane & Motor Co., as to the reason for the high cost of airplane valves, Mr. Williams said that the relatively small quantities in which such valves have to be produced are partly responsible for their being expensive, and the necessity of metallurgical inspection is another factor. The exceedingly close limits to which such valves must be finished also add to their cost.

To another query he replied that his company recommends a flat valve-seat face in preference to a curved face, because the former is easier to grind-in. Asked what is the chief cause of valves sticking, Mr. Williams said that in general there are two causes: gumming from the lubricant due to a decided change in temperature, and galling in the guides due to faulty design or the use of poor materials. Another speaker expressed the opinion that all such troubles are caused by expansion which, however, has been eliminated, he believes, where two cylinder-head gaskets are installed. This result apparently is due to reduced compression.

Questioned regarding the most suitable metal to be used for an inserted valve-seat, Mr. Williams stated that bronze and C.N.S. steel are being widely used, although in usual motor-car practice the cylinder material itself is satisfactory. While bronze seats, such as are used to a considerable extent in aluminum castings, may be threaded-in, he recommended pressing them into place.

Dinner Meeting in Toronto

FIFTY members and prospective members attended the dinner meeting of the Canadian Section in Toronto on March 13 at the King Edward Hotel. H. C. Mougey, chief chemist of the General Motors Corp. Research Laboratories, of Detroit, was the speaker of the evening, and after his address was kept busy for 20 min. answering a rapid fire of questions from the members. George P. Dorris, who began the manufacture of motor-cars in St. Louis in 1898, was also a guest of honor and was introduced by R. H. Combs, Chairman of the Section, who presided.

See Four Speeds Working

Motion Pictures and White's Description of Four-Speed Transmission Interest Indianians

AT the most satisfactory meeting held by the Indiana Section this season, the technical feature of the evening of March 14 was an exposition of the design and operation of a four-speed transmission. S. O. White, of the Warner Gear Co., explained orally and by lantern slides the construction of the mechanism. His exposition was most interestingly elucidated by a two-reel motion-picture film showing the internal operation of the transmission. This film was sent for the occasion through the courtesy of the Graham-Paige Motor Co.

Nearly 200 members and guests were in attendance. In the absence of Chairman Fred S. Duesenberg, Vice-Chairman George H. Freers presided. The technical session was preceded by a dinner and entertainment at the Hotel Severin roof garden in Indianapolis. For half an hour the members were kept mystified by tricks performed by the magician, C. R. Eggleston—a unique feature at an S.AE. meeting.

Discussion on the four-speed versus the three-speed transmission was supplemented by an informal description of a new device, called the Bakstop, to prevent backward rolling of a car on an incline. The description was given by W. Carlton Starkey, of the L.G.S. Mfg. Co., and, although designed to accomplish the same result as the Noback, the device is very dissimilar in details of construction.

The Section's Nominating Committee presented the names of nominees for offices for next year as follows: Bert Dingley, Chairman; Harlow Hyde, Secretary; and Charles Trask, Treasurer. Under the constitution of the Section, Chairman Duesenberg automatically becomes Vice-Chairman next year.

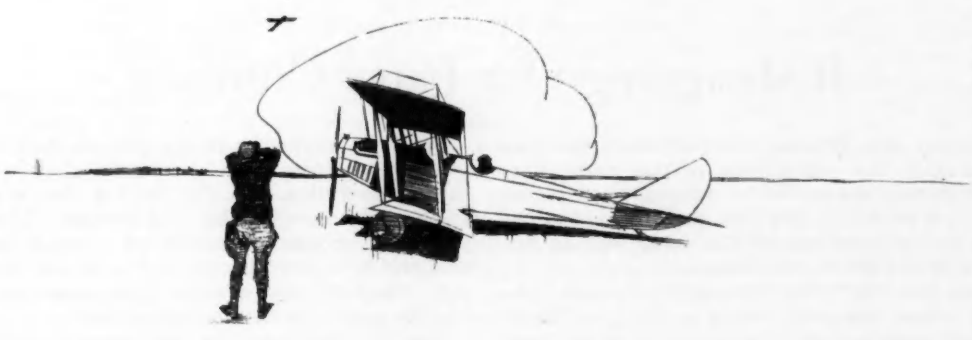
Inspection Trip in April

Hagerstown and Newcastle, Ind., are to be the locations of the April meeting on the 20th, which is to be a piston-ring production meeting. Ralph R. Teetor, chief engineer of the Perfect Circle Co., is to entertain the members. Inspection of the company's Hagerstown plant will occupy the forenoon, followed by luncheon in Hagerstown and a trip to the company's foundry at Newcastle. Special entertainment is to be provided from 3 to 5 p. m., and dinner is to be served in Newcastle at 6 p. m.

Plans have been made by D. McCall White to transport about 40 of the members on the trip in a large steam motorcoach of his own design and constructed under his supervision in Indianapolis.

Hermann Incorrectly Reported

IN the report of the engine session at the Aeronautic Meeting in Chicago in December, 1928, Otto Hermann, president of the Century Rotary Motor Corp., is reported on p. 5 of the January issue of the S.A.E. JOURNAL as having "mentioned a new type of engine, which he later stated to be of the semi-Diesel type, that had been developed by his company and extensively tested by the Army and the Navy." Mr. Hermann writes that he did not state that the engine had been so tested but that the engine is in a cowling which is being tested by the National Advisory Committee on Aeronautics and which gives the airplane from 15 to 20 per cent more speed.



Re-examination of Drivers

WHATEVER advance in safety has been made has been gradual and always because transportation emergencies have reached an acute stage, making a change of some kind absolutely necessary. So it is a forced conclusion that nothing will be done through public sentiment about any safety situation as such, but that to get action backed up by public sentiment the situation must embody in it an element of imperfect transportation which needs correction.

It is a sound argument that the reason sentiment cannot be roused is that the owner or the operator of every motor-vehicle is now so absolutely self-reliant that it would be impossible to make him believe that he is unfit to participate in the traffic of the day. In almost every instance of trouble occasioned by the operation of a motor-vehicle, there is on the part of one or the other of the individuals involved an unexpected reaction to circumstances, sometimes extreme and sometimes only unexpected, which such individual had believed could never happen to him.

Character Test of Good Operator

The members of the public will not accept safety as such, will not themselves do the regulatory acts and insist upon the cautious care so necessary unless they are trapped into it. If it be possible to make a traffic plan simple enough and easy enough to produce the result that each citizen will be able to go from place to place faster and with less annoyance, then it stands to reason more people will make use of it. When such a plan has proved its convenience, the people who use it will submit to almost any safety regulation which traffic authorities may impose.

With all of our emergencies and all of our advanced ideas and understanding—and we rate ourselves the most intelligent Nation in the world—it is still necessary to have a policeman watch almost every corner, even though automatic traffic direction is supplied. We are so independent and free in our ordinary activities from police supervision that we have learned to rely upon ourselves to serve our own convenience first, though the convenience of others may be disregarded. But how can the principle of government through moral suasion be better served in connection with traffic signals than to leave them unguarded by uniformed policemen and have, for a time at least, a plain-clothes person watch and discipline offenders? In that way within a very short time all traffic devices would be heeded by everyone, for in the mind of the operator each person standing around would be a potential detective.

To Weed Out Incapables

It is proposed that the State of Connecticut re-examine its drivers. The general idea is to set some reasonable time during which people may be supposed to change and to assume that at the end of that time it is fair to suppose that in the natural course of events the person has changed enough in his qualities, through age or otherwise, that he ought to be re-examined. This plan may be open to this criticism, that motor-vehicle operators ought not to become worse as they gain added experience with and added knowledge of the problem, and that the general plan as outlined is directed against a large body of good performers as well as against the bad performers. However, if it can be accomplished and done thoroughly, Connecticut will be the first State to weed out all of its incapables. If a re-examination of everybody could be had and thereafter a policy adopted by which every person who committed any offense whatever was at once re-examined by a high-grade examiner capable of studying human characteristics and under the direction of expert advice as to how to detect mental imperfections, it would not be long before the 12 persons out of the 100 who are making most of the trouble would be detected and to a large degree eliminated from traffic. It may be well to remark that there are still 3 persons out of the 100 to account for. They are of the criminal type, and it is not intended to deal with them here.—Robbins B. Stoeckel, Commissioner of Motor Vehicles, State of Connecticut.

Redesigning Our Paper Currency

FOR several years the Treasury Department has had under consideration the redesigning of our paper currency. The outstanding change to be accomplished is the reduction in size to 6 5/16 x 2 11/16 in., two-thirds that of the present bills and approximately the same size as the standard currency of the Philippine Islands.

During the fiscal year 1917, the Treasury delivered 514,688,180 pieces of paper currency, while in 1927, 992,339,984 pieces were delivered, a gain in a decade of 93 per cent in the annual demand for new bills. This large increase is due primarily to the greater exchange demands for paper money.

The growth in the number of automobiles in the Country has contributed definitely to the paper currency problem of the Treasury. The passage of paper money through the hands of service stations, with unavoidable accumulation of grease and dirt, appreciably decreases the average life of smaller-denomination bills. An experiment with dollar bills indicated that denominations of this size are spent one time in seven at service stations.

With the reduction in the size of the currency, it will be possible to make 12 notes instead of 8 from one sheet and in one operation, thereby raising the productive capacity of the printing plant by 50 per cent. The new bills, while not small enough to render all existing counting machines and registers obsolete, are still of a size which reduces folding. They will last much longer, remain in better condition, and be easier to handle and carry.

For the first time the signature of the Secretary of the Treasury will appear on each bill whatever its variety and denomination. Danger of counterfeiting will be lessened, since the protective engraving will be much smaller and finer and more difficult of imitation. The uniformity in bills of a denomination also will reduce the possibility of fraud through raising.

Since the early retirement of the National bank-note circulation, which has been under consideration for some years, is now deemed to be inadvisable, the Treasury Department will be prepared to issue shortly National bank-notes in the reduced size.—*Commerce Monthly.*

Personal Notes of the Members

Neracher Joins Chrysler

Carl A. Neracher, who for the last several years has done important work in connection with the development of the four-speed transmission, recently tendered his resignation as chief engineer of the Durant Motor Co. of New Jersey, at Elizabeth, to join the engineering staff of Chrysler Motors.

In the course of his engineering experience, Mr. Neracher has served as chief engineer for the Garford Co., the Willys-Overland Co., the Rainier Motor Corp. and the New Process Gear Corp. He acted as vice-president and assistant general manager as well as chief engineer of the last-named company, whose service he left in 1926.

Mr. Neracher became a Member of the Society in 1911, and of the Metropolitan Section in 1925, and has presented two constructive papers on the subject of transmissions: A Four-Speed Internal-Underdrive Transmission, appearing in the February, 1927, issue of THE JOURNAL; and New Transmission Developments, a paper submitted in connection with a symposium on transmissions at the Annual Meeting held in Detroit last January.

Michel's New Title

C. A. Michel, formerly chief engineer of the Guide Lamp Division of the Delco-Remy Corp., of Cleveland, has been named vice-president in charge of engineering of the Guide Lamp Corp. Mr. Michel became affiliated with this company in the summer of 1915, upon completion of his junior year at the Case School of Applied Science. After graduation he established a permanent connection with the Guide Motor Lamp Mfg. Co., as it was then named, becoming identified with the cost department. He subsequently acted in the capacity of engineer and production manager, and in 1922 was appointed chief engineer.

His membership in the Society dates back to 1917, when he was elected a Junior Member. In 1921 he was accorded full membership grade. He became a Cleveland Section member the year after he joined the Society.

Mr. Michel's knowledge of lighting problems has been of inestimable value to the Society in its standardization work. He has been a member of the Lighting Division of the Standards Committee since 1920. He served as Vice-Chairman of this Division for two years, and this year marks the beginning of his sixth consecutive term as Chairman. He has served several times on the Headlight Subcommittee of the Research Committee, and on the Sectional Committee on Motor Vehicle Lighting Specifications, which is sponsored by the Society. Last year he represented the Society on the Steering Committee on Headlight Research, which is a joint committee with the Illuminating Engineering Society.

An interesting contribution to Society literature was made by Mr. Michel in the form of a paper entitled, Desirable Road Illuminating, which was printed in THE JOURNAL of May, 1924.

Herrmann Resigns from Studebaker

Karl L. Herrmann has resigned as consulting engineer of the Studebaker Corp., of South Bend, Ind., to undertake the management of the Bantam Ball Bearing Co., of which he is the majority stockholder. This company is also located at South Bend. His experience in the engineering field, previous to this new enterprise, has been unusually comprehensive. In 1909 he joined the Studebaker Corp. as experimental engineer. He left Studebaker in 1912 to establish the Herrmann Engineering Co., in Detroit, but discontinued this activity in 1916 to accept the position of motor engineer with the Briscoe Motor Corp., of Jackson, Mich. In 1917, he renewed his connection with the Studebaker Corp., first becoming identified with the engineering department and later with the standards and methods department. In 1926 he was appointed consulting engineer.

Ever since becoming a Member of the Society in 1912, the standardization work has claimed Mr. Herrmann's active interest. He was elected First Vice-Chairman, in 1926, and Chairman, in 1927, of the Standards Committee. He has been a member of the Screw-Threads Division every year since 1924, acting as Vice-Chairman of this Division in 1928 and again this year. In 1925 he served on the National Meetings Committee and on the Chain Division of the Standards Committee. Last year he became a member of the Tire and Rim and the Transmission Divisions, of which he is still a member. At present he is serving his third consecutive term as a member of the Committee on Standardization Policy.

In addition to his invaluable service on the Standards Committee and its Divisions, Mr. Herrmann has contributed to the Society various technical papers of great interest, including the following: Some Causes of Gear-Tooth Error and Their Detection, contained in THE JOURNAL of November, 1922, and in Part II of TRANSACTIONS for that year; Tires as a Cause of Shimmy, published in the August, 1927, issue of THE JOURNAL; and Automobile Upholstery Leather, which appeared in THE JOURNAL for March, 1924. The last-named paper was prepared in collaboration with F. J. Radel.

Lowe Made Vice-President of Handy Governor Corp.

News of Edward F. Lowe's appointment as vice-president of the Handy Governor Corp., of Detroit, in New York City, was received with much interest by Society members. This appointment followed the merging of the K. P. Products Co., of which Mr. Lowe, formerly general manager, was named vice-president last September, with the Handy Governor Corp. Mr. Lowe has been associated with K. P. Products since 1922, when he severed his connection with the Monarch Governor Co. During the seven years he was with the Monarch Governor Co. he acted as sales manager as well as secretary and treasurer. Prior to making that connection, he was engaged in the manufacture of paint and varnish.

Mr. Lowe became an Associate Member of the Society and a member of the Metropolitan Section in 1924. Last year he was transferred to Member grade in the National organization. He has been prominent in the administration of the Metropolitan Section, having served as Treasurer in 1926, Vice-Chairman in 1927 and Chairman in 1928. He delivered a paper before the New England Section, outlining the characteristics of the internal-combustion-engine governor, which was published, together with discussion, in the September, 1925, issue of THE JOURNAL.

Forbes Becomes Executive Engineer

The appointment of Kingston Forbes as executive engineer of the Buick Motor Car Co. was recently announced. Prior to this promotion Mr. Forbes acted as body engineer for Buick. He acquired his basic engineering experience in England, his native country. In America, he served various companies as draftsman and designer before entering upon his connection as an engineer with the Buick Motor Car Co. in 1915. Seven years later he was appointed assistant body engineer, subsequently becoming body engineer.

Mr. Forbes was elected a Junior Member of the Society in 1912, and two years later was transferred to the

(Continued on page 40)

Applicants Qualified

The following applicants have qualified for admission to the Society between Feb. 10 and March 10, 1929. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALLEN, GEORGE FRANKLIN (M) vice-president, general manager, Hoyt Metal Co. of Canada, Ltd., 721 Eastern Avenue, *Toronto, Ont., Canada.*

ALLEN, HARRY GEORGE (A) Motor Rim & Wheel Service, 1367 South Flower Street, *Los Angeles.*

ANDERSEN, HAROLD B. (A) machine-shop owner, Simplex Machine Works, 616 Court C, *Tacoma, Wash.*

BAILEY, WILLIAM F. (A) service engineer, Earl B. Staley Co., *Seattle, Wash.;* (mail) 3238 61st Street.

BARLOW, LESTER P. (M) consulting engineer, machine design, inventing, McCord Radiator & Mfg. Co., East Grand Boulevard, *Detroit.*

BARNES, N. C. (M) sales engineer, Aluminum Co. of America, 3311 Dunn Road, *Detroit.*

BARTUSCH, ALEXANDER PAUL (J) mechanical engineer, Union Switch & Signal Co., Swissvale, Pa.; (mail) 1032 Mifflin Avenue, *Wilkinsburg, Pa.*

BATEMAN, ARTHUR T. (M) chief engineer, plant No. 3, Bohn Aluminum & Brass Corp., 2599 22nd Street, *Detroit.*

BEATON, JOHN H. (A) general sales manager, General Motors of Canada, Ltd., *Oshawa, Ont., Canada;* (mail) Box 125.

BECK, VERN G. (A) assistant service manager, Transport Motor Co., *Spokane, Wash.;* (mail) 2518 West Fairview.

BISHONDEN, FRANK (A) engineer, in charge of works, Metropolitan Motors, Ltd., Brisbane, Australia; (mail) Oisemond, Riverview Terrace, South Toowong, *Brisbane, Queensland, Australia.*

BLAIR, DAVID EDWARD (M) general superintendent, Montreal Tramways Co., 102 Craig Street, West, *Montreal, Que., Canada.*

BOLLES, J. H. (A) sales engineer, Delco-Remy Corp., 10-128 General Motors Building, *Detroit.*

BREWSTER, THEODORE A. (M) full-size-body draftsman, Pierce-Arrow Motor Car Co., Buffalo; (mail) 197 Tremont Ave., *Kenmore, N. Y.*

CARSON, WILLIAM L. (A) superintendent of machine shops, Washington Iron Works, *Seattle, Wash.;* (mail) 2216 Harvard Avenue, North.

CHAPLIN, W. R. (A) draftsman, designing plant equipment, Steel Co. of Canada, Ltd., Hamilton, Canada; (mail) 526 Beach Boulevard, Station 6, *Hamilton Beach, Ont., Canada.*

COLEMAN, WILLIAM R. (A) in charge of maintenance, Seattle auto equipment district, Standard Oil Co., *Seattle, Wash.;* (mail) 3220 17th Avenue, South.

DITCHBURN, HERBERT (M) president, manager, Ditchburn Boats, Ltd., *Cravenhurst, Muskoka, Ont., Canada.*

DITHMER, S. E. (J) assistant production manager, General Motors of Japan, Ltd., P. O. Box 151, *Osaka, Japan.*

DUNHAM, H. S. (A) shop foreman, automobile repair department, Earl B. Staley Co., *Seattle, Wash.;* (mail) R. F. D. 3, Box 199.

FAWVER, ARCHIE (A) layout draftsman, checker, Boeing Airplane Co., *Seattle, Wash.;* (mail) 3715 Magnolia Boulevard.

GARNER, GEORGE WESLEY (M) specification engineer, in charge of engineering and specification work, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

GILL, WILLIAM A. (A) president, manager, Gill Automotive Service Co., 290 Davis Street, *Portland, Ore.*

GLEN, CHARLES (M) foreman, Willys-Overland Co., Toronto, Canada; (mail) *Humberside P. O., Toronto, Ont., Canada.*

GOVE, WINFIELD D. (J) research engineer, dynamics division, General Motors Research Laboratory, *Detroit;* (mail) 16255 Monica Avenue.

GUNDERSON, CHESTER E. (A) president, Wheel & Rim Service, Inc., corner 14th and Everett Streets, *Portland, Ore.*

HAWKS, ARTHUR S. (M) assistant works manager, Buffalo Works, Worthington Pump & Machinery Corp., Clinton and Roberts Streets, *Buffalo.*

HUMKE, BEN M. (A) foreman, Central Garage & Machine Co., Inyo and K Streets, *Tulare, Calif.;* (mail) R. C. Box 330.

IRVINE, ANDREW (A) superintendent machine shop, pattern division, Bohn Aluminum & Brass Corp., *Detroit;* (mail) 4105 Balfour Road.

KING, ARTHUR W. (A) general superintendent, assembly division, Willys-Overland Co., *Toledo, Ohio;* (mail) 3307 Collingwood Avenue.

KRIETER, HARRY RUDOLF (J) assistant superintendent and engineer, in charge of development, Burgess-Norton Mfg. Co., *Geneva, Ill.;* (mail) 19 McKinley Avenue.

KRUEGER, E. W. (J) assistant chief engineer, automotive division, Cleveland Pneumatic Tool Co., 3734 East 78th Street, *Cleveland.*

LEISY, CLIFFORD J. (J) staff engineer, Glenn L. Martin Co., Baltimore; (mail) 2071 East 224th Street, *Euclid Village, Ohio.*

LEVON, WALTER P. (J) body draftsman, Chrysler Corp., *Highland Park, Mich.;* (mail) 20155 Greeley Avenue.

LIGGETT SPRING & AXLE CO., INC. (Aff.) Monongahela, Pa. Representatives: Adams, A. A., district sales manager, Chicago; Cochrane, J. L., secretary, treasurer.

MCCUE, NORBERT D. (A) superintendent of transportation, Great Atlantic & Pacific Tea Co., *Chicago;* (mail) 2622 North Crawford Avenue.

MOREHOUSE, WILBUR RAYMOND (A) operation and maintenance manager, Morehouse Baking Co., 7 Mill Street, *Lawrence, Mass.*

PARK, W. GORDON (M) superintendent, Military plant, Kelsey Hayes Wheel Corp., *Detroit;* (mail) 9919 Pinehurst Avenue.

PILLING, HARRY (A) service manager, Southard Motors, Ltd., West, *Vancouver, B. C.;* (mail) Suite 5, 855 Thurlow Street.

PITZER, REGINALD CYRUS (A) sales engineer, Willis Jones Machinery Co., 2418 Ninth Avenue, South, *Seattle, Wash.*

PONTI, COLUMBUS F. (J) electrical engineer, International Motor Co., Long Island City, N. Y.; (mail) 2187 Arthur Avenue, *New York City.*

POWELL, H. EMERSON, JR. (J) instructor, automobile mechanics, senior high school, Board of Education, South Orange, N. J.; (mail) 53 Kirk Street, *West Orange, N. J.*

RICKERT, HAROLD T. (M) assistant to general manager, motor transport department, Pure Oil Co., *Chicago;* (mail) 1630 East 70th Street.

RULLISON, E. A. (M) engineer, Tillotson Mfg. Co., *Toledo, Ohio;* (mail) 2538 Foraker Avenue.

RUSHTON, BENJAMIN (F M) technical manager, Delco-Remy-Hyatt, Ltd., London; (mail) 31 Brodrick Road, Wandsworth Common, *London S. W. 17, England.*

RYAN, RALPH B. (A) president, general manager, Cox Cylinder Works, 417 23rd Street, *Oakland, Calif.*

SEGHERS, JOSEPH P. (A) service superintendent, Moreland Motor Truck Co., *Portland, Ore.;* (mail) 363 Oregon Street.

SIZAIRE, MAURICE HYPPOLITE L. (F M) consulting engineeer, Sizaire Freres, Courbevoie, France; (mail) 15 Boulevard de Belgique, *Le Vosinet, Seine et Oise, France.*

SKILLINGS, C. T. (A) salesman, Autocar Sales & Service Co., *Oakland, Calif.;* (mail) 2128 East 30th Street.

SMITH, WILLIAM E. (M) superintendent of welding, Ford Motor Co., *Detroit;* (mail) 3539 Oakman Boulevard.

SOROKIN, MARK L. (A) president, managing director, Automobile Trust, *Moscow, U. S. S. R.;* (mail) Miasnitskay 20, Awtotrest.

STARR, CHESTER H. (A) vice-president, general manager, Willard Storage Battery Co. of Canada, Ltd., 269 Campbell Avenue, *Toronto 9, Ont., Canada.*

STEPHENS, H. M. (A) general sales manager, Cadillac Motor Car Co., *Detroit.*

STIRK, JOHN HARDACRE (F M) traffic manager, Birmingham Cooperative Society, Ltd., Birmingham, England; (mail) Wilowcroft 4, Holly Lane, *Erdington, Warwickshire, England.*

STOBBE, LOUIS G. (J) layout draftsman, chassis, Dodge Brothers, Inc., *Detroit;* (mail) 9669 North Martindale.

THEDGAR, VICTOR L. (J) engine and chassis layout, Hupp Motor Car Corp., *Detroit;* (mail) 14102 East Jefferson Avenue.

TITTENSOR, PERCY (A) metal pattern department, on Keller work, Buick Motor Co., *Flint, Mich.;* (mail) 1545 New York Avenue.

TUCEK, JERRY (F M) service manager, Ceskomoravska-Kolben-Danek, Prague, Czechoslovakia; (mail) *Prague VIII 205, Czechoslovakia.*

WEICK, FRED E. (S M) aeronautical engineer, in charge of propeller research section and 20-ft. propeller research tunnel, National Advisory Committee for Aeronautics, *Langley Field, Va.*

WILLIAMS, CLIFFORD V. (A) sales engineer, Delco-Remy Corp., Anderson, Ind.; (mail) 10-128 General Motors Bldg., *Detroit.*

WULF, RAYMOND H. (M) president, treasurer, American Tube Bending Co., 5 Lawrence Street, *New Haven, Conn.*

Applicants for Membership

Ainsley, Walter G., experimental engineer, Sinclair Refining Co., *East Chicago, Ind.*

Angeles, Marciano S., Box 1208, *Baton Rouge, La.*

Baxter, V. A., lubrication engineer, Midwest Oil Co., *Minneapolis.*

Booth, Wilber, district foreman, Shell Oil Co., *Oakland, Cal.*

Brown, Hanson Ames, vice-president and general manager, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

Brown, Marcus L., Jr., factory manager, Seiberling Rubber Co. of Canada, Ltd., *Toronto, Ont., Canada.*

Caesar, O. S., president and general manager, Motor Transit Corp., *Chicago.*

Cave-Browne-Cave, Myles V., service repair department, Cave's Motor Agency, *Birmingham, England.*

Crist, Russell A., assistant to vice-president, engineering division, General Motors Truck Corp., *Dayton, Ohio.*

Dailey, H. P., vice-president, Wolverine Flying Service, Ltd., *Kalamazoo, Mich.*

Davis, W. E., assistant general manager, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

Davis, W. F., project engineer, Wright Aeronautical Corp., *Paterson, N. J.*

Densham, Eric William, technical representative, Bristol Aeroplane Co., Ltd., *Bristol, England.*

Downey, A. C., general purchasing agent, Chrysler Corp., *Detroit.*

Doyle, Frank B., designer, Ingersoll-Rand Co., *Phillipsburg, N. J.*

Dunning, William A., draftsman, New Standard Aircraft Co., *Paterson, N. J.*

Eddy, Harry C., traffic engineer, Board of Public Utility Commissioners, State of New Jersey, *Newark, N. J.*

Egloff, Gustav, Universal Oil Products Co., *Chicago.*

Eisenmann, Samuel B., student, New York University, *New York City.*

Ellis, Frank Alexander, service supervisor, Dodge Brothers (Canada), Ltd., *Toronto, Ont., Canada.*

Euker, Edwin M., layout draftsman, Packard Motor Car Co., *Detroit.*

Ferguson, Kenneth J., checker, drafting department, Johnson Motor Co., *Waukegan, Ill.*

Frankenfield, Fred, machinist, Pitcairn Aviation, *Bryn Athen, Pa.*

Freyer, Herman A., machine-shop foreman, Fokker Aircraft Co. of America, *Glendale, W. Va.*

Githens, Thomas Francis, mechanical engineer, Cleveland Twist Drill Co., *Cleveland.*

Gossard, Alvin H., manager automotive department, Middle West Utilities Co., *Chicago.*

Grigsby, Howard Ray, superintendent of transportation, Oklahoma Gas & Electric Co., *Oklahoma City, Okla.*

Hall, Randolph F., second vice-president and chief engineer, Cunningham-Hall Aircraft Corp., *Rochester, N. Y.*

Haworth, Harold F., chief engineer, Leyland Motors, Ltd., *Leyland, Lancashire, England.*

Heath, Harold, Rootes, Ltd., Piccadilly, *London, England.*

Herridge, Edward, western service representative, Chrysler Corp., *Windsor, Ont., Canada.*

Hillman, Henry A., plant engineering department, Chrysler Corp., Highland Park Plant, *Detroit.*

The applications for membership received between Feb. 15 and March 15, 1929, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

Hodgson, Richard Walker, mechanical engineer, Melville Motor Co., *Melville, Sask., Canada.*

Jack, W. E., lubrication engineer, lubricating department, Skelly Oil Co., *Tulsa, Okla.*

Jenkin, William G., president, Jenkin-Guerin Oil Co., *St. Louis.*

Jensen, Carl Herman, in charge of metal department, art and color section, General Motors Corp., *Detroit.*

Jouffret, Henri, ingenieur d' etudes, Societe Anonyme Andre Citroen, *Paris, France.*

Laing, George, lecturer in motor engineering, Druleigh College, *Auckland, New Zealand.*

Larsen, Victor August, stress analysis, New Standard Aircraft Corp., *Paterson, N. J.*

Lawrence, Russell E., dean of engineering college, University of Detroit, *Detroit.*

Lee, Thomas, general superintendent, Sturgess Multiple Battery Corp., *Jamaica, N. Y.*

Leeper, Ernest W., head of mechanical arts department, Garfield High School, *Los Angeles.*

Lindsay, Charles H., resident engineer, American LaFrance & Foamite Corp., *Utica, N. Y.*

MacDonald, Horace D'Orsay, service manager, Bowell, McDonald Motor Co., Ltd., *Vancouver, B. C.*

Mangold, Rudolf, mechanical engineer, chief draftsman, Robert Bosch Magneto Co., Inc., *Long Island City, N. Y.*

Manly, G. B., director of instruction, Chicago Motor Training Corp., *Chicago.*

Marko, Jerome A., layout draftsman, Continental Motors Corp., *Detroit.*

Marshall, Edward O., brake engineer, Manhattan Rubber Mfg. Co., *Passaic, N. J.*

Martain, Leslie Roger, machinist, Willis-Jones Machinery Co., Inc., *Seattle, Wash.*

Maunu, Leonard M., designer and draftsman in mechanical engineering, Briggs & Stratton Corp., *Milwaukee.*

McClintock, Miller, research director, Albert Russell Erskine Bureau, Harvard University, *Cambridge, Mass.*

McElroy, Bernard M., salesman, Hoover Spring Co., *San Francisco.*

McIntosh, W. Ralph, sales promotion, McLaughlin Motor Car Co., Ltd., *Toronto, Ont., Canada.*

McKibben, J. Scott, experimental engineer, Graham-Paige Motors Corp., *Detroit.*

McLellan, William Lumsden, service manager, Glyde & McLellan, Ltd., *Edmonton, Alta., Canada.*

Merrill, Louis F., chief designer, aircraft division, Continental Motors Corp., *Detroit.*

Miller, L. E., service manager, Patriot Mfg. Co., *Haverlock, Neb.*

Mooney, A. W., chief engineer, Alexander Industries, Inc., *Colorado Springs, Colo.*

Mortimer, James Benzies, on technical service staff, General Motors of Canada, *Oshawa, Ont., Canada.*

Morton, Hudson T., Jr., metallurgist, Hoover Steel Ball Co., *Ann Arbor, Mich.*

Muther, Walter P., president, Muther Mfg. Co., *Boston.*

Myers, H. B., superintendent machine division, Ferro Machine & Foundry Co., *Cleveland.*

Myers, William A., Jr., assistant engineer, E. G. Budd Mfg. Co., *Philadelphia.*

Nygren, Ernest E., chief draftsman, Leece-Neville Co., *Cleveland.*

Nyquist, Walter Irvin, assistant to body engineer, Dodge Brothers, Truck Division, *Detroit.*

Penther, Herbert, editor, for technical service, *Allgemeine Automobile Zeitung, Vienna, Austria.*

Peterson, Norman H., general service manager, Packard Motor Car Co. of Chicago, *Chicago.*

Rogan, Thomas F., chief inspector, Continental Motors Corp., *Detroit.*

Rootes, William Edward, managing director, Rootes, Ltd., *London, England.*

Rosenbaum, Bernard, president, Rosie's Sales & Service Corp., *New Rochelle, N. Y.*

Schowalter, Clarence H., student, post graduate course, New York University, *New York City.*

Roy, H. F., Ross Roy Specification Service, *Detroit.*

Rubert, Kennedy F., research fellow, Sherman Fairchild Fellowship, College of Engineering, New York University, *New York City.*

Russell, Linus E., president, Peters & Russell Inc., *Springfield, Ohio.*

Schmidt, Lindsay, student, Colorado Agricultural College, *Fort Collins, Colo.*

Schneider, Adolf G., designer, Lycoming Mfg. Co., *Williamsport, Pa.*

Schroyer, Lewis A., superintendent of maintenance, Yellow Cab Co., *San Francisco.*

Smith, S. Harold, experimental engineer, automotive division, Smith Incubator Co., *Cleveland.*

Slater, William C., master mechanic, Berkeley Tire Department, *Berkeley, Cal.*

Snidow, Robert C., temporary student, *Camp Holabird, Md.*

Soutter, Arthur W., maintenance engineer, Rolls-Royce of America, Inc., *Springfield, Mass.*

Tripp, Harry F., brake expert, 564 20th St., *Oakland, Cal.*

Tubbs, E. J., chief engineer, Cleveland Steel Products Corp., *Cleveland.*

Utz, Chester C., checker and designer, Packard Motor Car Co., *Detroit.*

Vivers, Robert, Jr., superintendent, The White Co., *Newark, N. J.*

Vidican, John P., complete automobile body designer, Oakland Motor Car Co., *Pontiac, Mich.*

Wieden, Camillo, draftsman, Winton Engine Co., *Cleveland.*

Wilhelm, Howard A., electrical appliance, Rock Island Mfg. Co., *Rock Island, Ill.*

Williams, Roland, foreign commercial sales student, International Harvester Co., *Chicago.*

Willy, George R., mechanic, Community Motors, *Chicago.*

Whyte, Jessel S., vice-president, general manager, Mac Whyte Co., *Kenosha, Wis.*

Notes and Reviews

AIRCRAFT

The Variation in Engine Power with Altitude, Determined from Measurements in Flight with a Hub Dynamometer. Report No. 295. By W. D. Gove. Published by the National Advisory Committee for Aeronautics, City of Washington; 12 pp., illustrated. [A-1]

The rate of change in power of aircraft engines with altitude has been the subject of considerable discussion, but only a small amount of data from direct measurements of the power delivered by airplane engines during flight has been published. This report presents the results of direct measurements of the power delivered by a Liberty-12 airplane engine taken with a hub dynamometer at standard altitudes from zero to 13,000 ft. Six flights were made with the engine installed in a modified DH-4 airplane.

The experimental relation of brake horsepower to altitude is compared with two theoretical relations and with the experimental results, for a second Liberty-12 engine, given in N.A.C.A. Technical Report No. 252. The rate of change in power with altitude of a third Liberty engine, measured with a calibrated propeller, is also given for comparison.

The data presented substantiate the theoretical relation of brake horsepower to altitude based on the correction of ground-level indicated horsepower for changes in atmospheric temperature and pressure with the subsequent deduction of friction horsepower corrected for altitude.

Pressure Distribution Tests on PW-9 Wing Models from —18° Through 90° Angle of Attack. Report No. 296. By Oscar E. Loeser, Jr. Published by the National Advisory Committee for Aeronautics, City of Washington; 21 pp., illustrated. [A-1]

The increased speeds and maneuverability of modern pursuit airplanes call for careful consideration of design and of wing loads over a large range of angle of attack. Similarly, the consideration being given to stability and control above the stall requires an extension of the usual range of pressure distribution investigations. To this end, at the request of the Army Air Corps, the distribution of pressure over the wing models of a modern pursuit airplane, PW-9, was investigated in the wind-tunnel of the National Advisory Committee for Aeronautics. The results for the range of normal flight have been given in N.A.C.A. Technical Report No. 271. The present paper presents the same results in a different form and includes, in addition, those over the greater range of angle of attack.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J. Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

The Reduction of Observed Airplane Performance to Standard Conditions. Report No. 297. By Walter S. Diehl. Published by the National Advisory Committee for Aeronautics, City of Washington; 27 pp., illustrated. [A-1]

This report shows how the actual performance of an airplane varies with air temperature when the pressure is held constant. This leads to comparatively simple methods of reducing observed data to standard conditions. The new methods may be considered exact for all practical purposes, according to the author, and have been used by the Navy Department for about a year with very satisfactory results.

A brief historical review of the important papers published on the subject of performance reduction is also given, and the development of the standard atmosphere is traced.

Effect of Variation of Chord and Span of Ailerons on Rolling and Yawing Moments in Level Flight. Report No. 298. By R. H. Heald and D. H. Strother. Published by the National Advisory Committee for Aeronautics, City of Washington; 19 pp., illustrated. [A-1]

This report presents the results of an investigation of the rolling and yawing moments due to ailerons of various chords and spans on two airfoils having the Clark-Y and U.S.A.-27 wing sections. Some attention is devoted to a study of the effect of scale on rolling and yawing moments and to the effect of slightly rounding the wing tips.

The results apply to level flight with the wing chord set at an angle of attack of +4 deg. and to conditions of zero pitch, zero yaw, and zero roll of the airplane. It it planned later to extend the investigation to other altitudes for monoplane and biplane combinations.

The work was conducted in the 10-ft. wind-tunnel of the Bureau of Standards on models of 60-in. span and 10-in. chord.

On the Interference of Wind-Tunnel Walls of Rectangular Cross-Section on the Aerodynamical Characteristics of a Wing. Report No. 44. By Kwanichi Terazawa. Published by the Aeronautical Research Institute, Tokio Imperial University, Japan; 81 pp. [A-1]

The author discusses the work of Prandtl and of Glauert on the theory of interference of wind-tunnel walls upon the aerodynamical characteristics of an airfoil under test. Prandtl made a calculation on the so-called added drag of an airfoil situated at the central part of a wind-tunnel of circular cross-section, assuming semi-elliptic distribution of lift; Glauert developed the theory for the case in which the section of the wind-tunnel is rectangular. According to the author of the present report, certain factors were neglected which cause a deviation of the formula from experimental results.

Report No. 46 of the Tokio Imperial University, entitled, On the Effect of the Wall of a Wind-Tunnel upon the Lift Coefficient of a Model, by Tatudiro Sasaki, treats of the correction factor for lift coefficient in various types of wind-tunnel.

The Technical Development of the Aeroplane. By John D. North. Published in the *Journal of The Royal Aeronautical Society*, January, 1929, p. 1. [A-1]

Mr. North is regarded as one of the foremost designers in England. Since early in 1911 he has devoted his activities exclusively to aeronautics and for many years has been responsible for the design of all aircraft produced by Boulton & Paul, of Norwich. According to Mr. North, the technical development of the airplane falls under two heads: (*a*) development for the purpose of obtaining better results than those yielded by present standard good practice; and (*b*) perfection of technique, so that a designer's expectations may be realized with certainty and that results not worse than standard good

(*Continued on next left-hand page*)